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Foreword.

Mr. Mackenna's book brings out very clearly that although a certain amount of work, spasmodic and intermittent in character, was done before 1905, it is only within the last ten years that scientific agriculture has been seriously taken up in India. Ten years ago Lord Curzon, greatly assisted by Sir Edward Law and Sir Denzil Ibbetson organized the Department on its present lines and although a great deal of spade work had to be done, an excellent beginning has been made and results of real value have already, within this short period, been achieved.

The band of zealous workers who labour to benefit the people of India have before them great opportunities and if the work so well begun be steadily continued an economic revolution should, within the next twenty years, be effected in this country, especially if the co-operative organization be utilized to the full in making known the results of research and experiment.

R. W. CARLYLE.

SIMLA :
The 30th June 1915.

Preface.

This is not a text-book of Indian Agriculture. It is merely an attempt to give, in brief compass, an account of the efforts which have been made, from time to time, to improve it, and to indicate the main lines on which the Agricultural Departments have been working since their re-construction in 1915. For any opinions expressed the author is solely responsible.

I desire to express my acknowledgments to the Directors of Agriculture in the various provinces for the cordial way in which they have assisted me in the compilation of this book.

In particular I am indebted to Mr. and Mrs. Howard, Dr. C. A. Barber and Mr. R. S. Finlow for much valuable help in the preparation of the chapters dealing with the crops on which they are specially engaged.

J. MACKENNA.

MYAUNGMYA :
The 10th July 1915.

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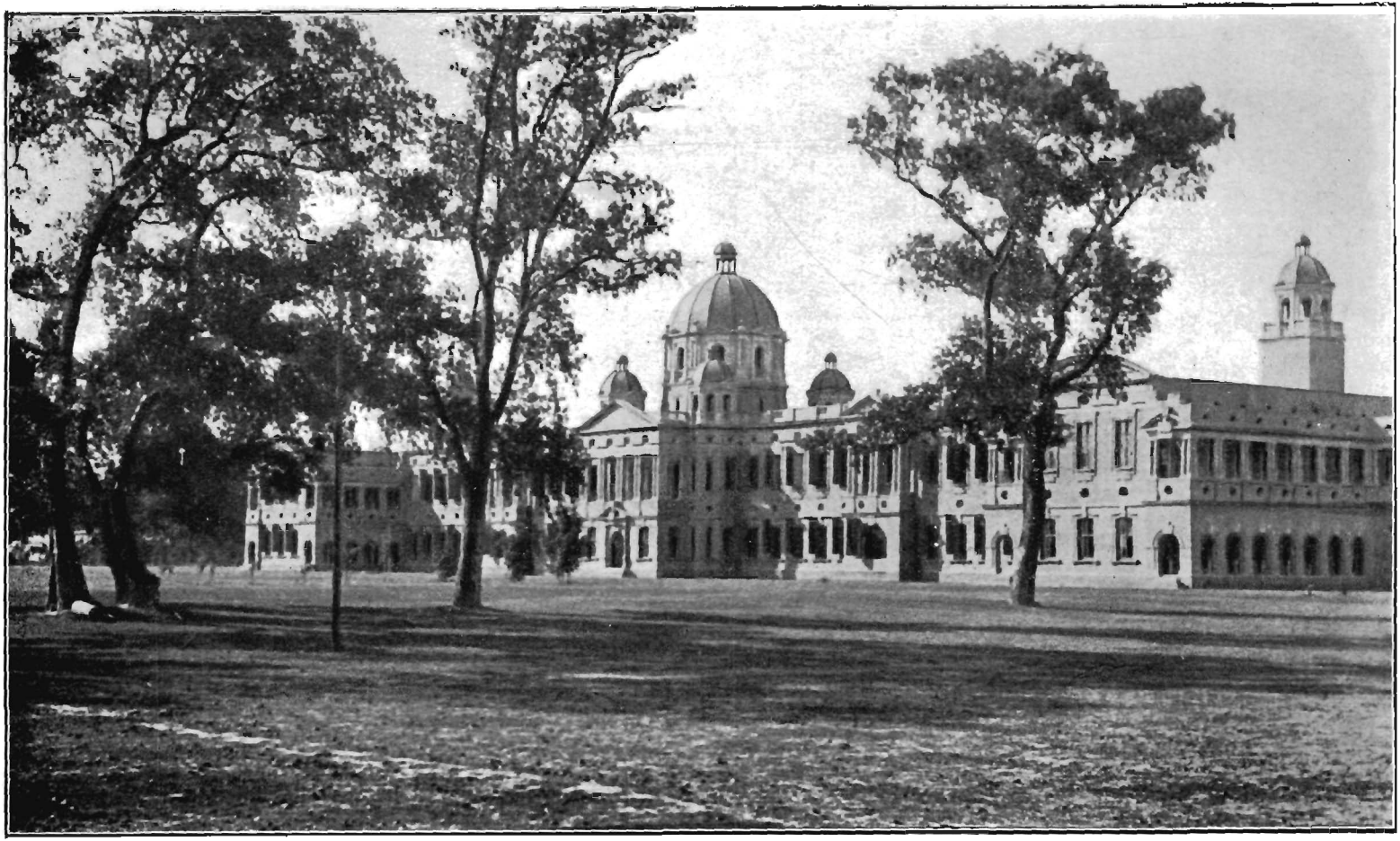

AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE, PUSA.

AGRICULTURE IN INDIA.

CHAPTER I.

Historical.

1866—1879.

Of the industries of India agriculture is, by far, the greatest and in a rough estimate recently made the annual value of the agricultural produce of British India is taken at over 1,500 crores of rupees or £1,000,000,000. Of its immense population at least two hundred millions are dependent for their livelihood on agriculture or the industries subsidiary to it and, except in the few manufacturing cities, the atmosphere is altogether agricultural. Over vast tracts of the country the only common interest is agriculture: the monsoon, the state of the crops, the health of the cattle.

Of the new-comers to the East many find themselves in congenial surroundings. They have had an early and close connection with rural life. They have been brought up in the country and to them "rural sights and rural sounds" appeal. If they have not had these early advantages, they soon become infected by the charm. They find that the one subject which interests the people amongst whom their lot is cast is their crops and their cattle. They are brought into contact with a peasantry whose interests seldom extend beyond the limits of their fields and their simple village life. These interests appeal strongly to them and the desire to assist in the rural development of the country becomes an ambition. How can the labours of these silent toilers be aided? How can their material condition be improved?

Such problems have again and again come into particular prominence and especially when the dark shadow of famine falls on India. The rains fail; the crops wither; the cattle die.

It is at such times that men's thoughts turn to the means of obviating these disasters, and the problem of ensuring a greater certainty of crops, either by the introduction of drought-resisting varieties or by the extension of irrigation, becomes a pressing one. Thus the great famine in Bengal and Orissa in 1866 first raised the question of an Agricultural Department. But the project did not find favour and the more practical view was taken that money might better be spent on irrigation, the results of which were obvious and immediate.

The formation of a separate Department of Agriculture was first seriously considered by Lord Mayo's Government in 1869. Outside pressure had been brought to bear by the Manchester Cotton Supply Association in a representation to the Secretary of State. Though primarily interested in cotton, they urged the establishment of a Department of Agriculture in each province and the more active employment of district officers in matters connected with cotton cultivation.

In some quarters (as has always been the case) the idea of an Agricultural Department doing any real good was scouted and the familiar argument was used that the cultivator knew his own business best. But this counsel did not prevail and proposals were submitted by the Government of India for the formation of a Department of Agriculture, under the supervision of a specially qualified officer, to be called Director-General of the Department of Agriculture and Commerce. This officer was to be charged with the superintendence of all measures connected with revenue, agriculture, forests, commerce and the industrial arts of India.

The proposal to send out a specially trained officer as Director-General of Agriculture was not sanctioned, but in his place an additional Secretary was added to the Government of India and placed in charge of revenue, agriculture and commerce. No scientific officers were employed either by the Government of India or in provinces. Nothing in the way of agricultural development was achieved and attention was limited entirely to the collection of statistics. In 1879, under the stress of financial pressure, the new secretariat was absorbed in the Home Department.

1880—1904.

The report of the Famine Commissioners of 1880 revived the question. Their scheme contemplated, as before, a central department controlled by the Imperial Secretariat, but they insisted on the absolute necessity of the simultaneous formation, in each province, of a Department of Agriculture, with a large subordinate establishment under an executive officer. This part of their proposals was indeed the corner-stone of the main administrative reforms which they projected. Mr. (now Sir Edward) Buck was appointed Secretary and under his guidance the development of provincial agencies was at once taken in hand. *Agricultural enquiry, agricultural improvement* and *famine relief* were laid down as the duties of the new departments, and Directors of Agriculture were appointed in most provinces.

The record of provincial development, described in a subsequent chapter, will show that the work was largely statistical and that little was done in the way of systematic agricultural improvement. In point of fact, the Government of India had, themselves, in a Resolution published in 1881, decided to postpone agricultural improvement until the scheme of agricultural enquiry had been completed, and provincial departments seem, in most cases, to have followed this instruction to the letter.

But, in any case, it would have been difficult at that stage to have made any advance. Agricultural science was in a very backward state in England. In agricultural chemistry alone had any great progress been made, and the supply even of trained chemists was small. The earlier proposals for the recruitment of an agricultural staff were confined to chemists and the employment of trained agriculturists was hardly mentioned.

Between 1881 and 1889 various questions were considered. The appointment of an agricultural chemist to the Government of India was discussed and a proposal to attach an agricultural branch to the Dehra Dun Forest School and to utilise it as a National School of Agriculture for Northern India also came to nothing.

No real progress was, indeed, made until the Secretary of State took a line of his own and, at the end of 1889, sent out Dr. Voelcker of the Royal Agricultural Society to advise as to the best way of applying the teachings of agricultural chemistry to Indian agriculture. Dr. Voelcker arrived in India towards the end of 1889 and left early in 1891. He toured over India meeting representatives of all provinces and the record of his journeyings and impressions is contained in his book "Improvement of Indian Agriculture." Dr. Voelcker did not share the view so commonly held that Indian agriculture was primitive and backward. He believed that in many parts of India there was little or nothing that could be improved, while, where agriculture was manifestly inferior it was more generally the result of the absence of facilities which exist in the better districts than of inherently bad systems of cultivation. That improvement, however, was possible was clear from the differences of agricultural conditions and practice found in different parts of India. He recommended therefore the systematic prosecution of agricultural enquiry and the spread of general and agricultural education and laid down, in considerable detail, the lines on which agricultural improvement was possible.

A conference of provincial delegates was held to discuss these proposals. The possibilities of improvements, it was agreed, were sufficiently great to justify the gradual establishment of a sound system of scientific investigation and of agricultural education. With regard to the general character of this system, it was agreed that an expert was required *for the purposes of scientific investigation* apart from the requirements of agricultural education and great stress was laid on the importance of having a man able to deal with the practical side of agricultural questions and competent to direct general enquiries. The conference concluded by advising the appointment of a really first-class man as agricultural chemist (for the conduct of general investigation) and an assistant (for purposes of instruction). An agricultural chemist and an assistant chemist were accordingly selected and arrived in November 1892. The duties of the senior officer were research; of the

junior, teaching at Poona, Dehra Dun and Saidapet and the disposal of chemical questions connected with forests and agriculture. Thus, in a modest way, was laid the foundation of a scientific staff for the Agricultural Department.

The next decade saw a marked development in the scientific side of the work. The need for something more than chemistry was being felt and interest in agricultural development was increasing in the provinces. Agricultural science, moreover, was becoming better organised in Europe.

In 1897, in view of the considerable development in the provinces, it was thought that the time was ripe for the appointment of an Inspector-General of Agriculture, but great difficulty was experienced in finding a suitable man and it was not till 1901 that the vacancy was filled by the appointment of Mr. J. Mollison, who for some years had been doing excellent work as a Deputy Director of Agriculture in Bombay. Broadly speaking his duties were to act as an adviser in agricultural matters both to the Imperial and Provincial Governments. Attention was at once directed to the expansion of the Imperial department, which, at this stage, consisted only of an agricultural chemist (in addition to the Inspector-General of Agriculture). A cryptogamic botanist (now known as the Imperial Mycologist) was added in 1901 and an entomologist in 1903.

Such were the beginnings of agricultural policy—if it can be called a policy. Early endeavours were too ambitious and the machinery—a centralised secretariat—was imperfect. The object aimed at was to increase the revenues of India by the improvement of agriculture; but nothing was done for that improvement, and the expansion of the land records staff and the compilation of statistics almost entirely occupied the attention of the provincial departments. But the foundation had been laid and the next few years were to witness a rapid development.

From 1885 there were definite strivings after something practical. Agricultural chemistry, it was thought, was the one essential, and this was not unnatural as English agricultural science to the ordinary man meant Lawes and Gilbert—both

chemists—at Rothamsted, and Voelcker—also a chemist—in London. Interest in general agricultural science had not yet awakened, as it did later, under the stimulus of a demand from the colonies.

Towards the end of the last century there was a great revival in agricultural science in England, and even in India the demand for scientific workers became insistent. There were indications of a keenness for agricultural research in India before the facilities for giving effect to it became available. When scientific workers did arrive they found that the years that had gone were not altogether barren, as, if no definite scientific progress had been made, a great deal of valuable information had been accumulated.

CHAPTER II.

Work in the Provinces before 1904.

It has already been remarked that most people bring to India, or soon develop, an enthusiasm for its agriculture. But with this enthusiasm there is generally linked, at the outset, a conservative preference for all that is Western. It is assumed that the Indian cultivator knows nothing about his own business: that anything that is good must come from the West. And so the kindly, but in many cases, misdirected, efforts of early workers took the line of introducing into India crops or implements of Western origin, regardless altogether, in the case of crops, of the effect of climatic change, or, in the case of implements, of considerations of cost.

This feeling died hard. It was long before the stage was passed of considering that the West must teach the East, that the East had nothing to teach the West. Real progress came only when it was realised that in India we have to deal with an agricultural practice which has been built up on the traditional custom of years and in which reside, though unexpressed and unexplained, deep scientific principles, the reasons for which can only gradually be elucidated.

But the labours of these early enthusiasts were not altogether in vain. A stimulus had been created, a basis had been laid for an Agricultural Department when the time was ripe. A few new crops proved successful and were established; a few implements were found suitable to local requirements. But there was no continuity or system. One man sowed but another did not reap; or, if he did, he did not trouble himself about the produce or retain the seed for further sowing, and the new crop was lost. There was no attempt to obtain from these isolated experiments any lessons of general application. Again, all men's interests are not the same, and the frequent transfers of officers led to the abandonment of experiments which, if systematically continued, might possibly have yielded important results. Progress depended mainly on the spasmodic

efforts of individuals keenly interested in the subject rather than on organised and continuous departmental action, and with the transfer of an officer who had initiated some experiment interest in it ceased.

These influences colour the earlier efforts in the provinces; but it is only just that these efforts should be recorded, not only that credit may be given where it is due, but also to bring into bolder relief the early causes of failure.

Bombay.—The Government of Bombay had from a very early date interested themselves in agricultural improvements. Cotton was one of the first Indian products to attain commercial importance and to the improvement of the cotton crop early efforts in Bombay were chiefly directed. They are reported as early as 1788, but little good appears to have resulted. It is interesting to note that in 1839 the Court of Directors sent to India twelve American planters to teach the people of the country an improved way of ginning and cleaning cotton. They found that the people had nothing to learn as regards picking, and that a small additional price was all that was necessary to induce them to clean cotton better. Efforts to introduce exotics, conducted by these planters and by private agency, entirely failed. In 1870 the experiments were abandoned and efforts were made to improve the indigenous variety in Broach and Surat and to select better seed. The operations were, however, found to be very expensive and the experiments were abandoned. But Bombay was working on right lines.

In Khandesh persistent and continuous efforts were made to introduce American cotton, and, after many vicissitudes, " Dharwar American " was established on a firm footing. The early history of agriculture in Bombay is the patient persistence with which these experiments were conducted. The introduction of exotic tobacco and wheat also engaged attention and, with the former, some success was achieved.

A Director of Agriculture was appointed in 1883, and, although his duties were for the first decade largely statistical, agricultural work was not neglected. In 1890 a Superintendent of experimental farms was sanctioned, and work on the

improvement of agriculture on scientific lines was commenced. Mr. J. Mollison, late Inspector-General of Agriculture in India, was appointed to the post and under his capable administration the department was organised and the subordinate staff which he trained reached a high degree of efficiency.

Madras.—To Sir William Denison, Governor of Madras, is to be ascribed the credit of founding in 1863 the Madras Department of Agriculture. But his Government fell into the mistakes we have already noted of turning for aid to the West, and their first act was to order from England a steam plough, some harrows and cultivators, seed-drills and horse-hoes, threshing-machines and winnowers, chaff-cutters and water-lifts. As Mr. Chadwick remarks, it was perhaps natural that thoughts at first flew to the material aids of Western agriculture and that the need for trained observers was not recognized. That stage indeed had not been reached even in England.

To find employment for this elaborate consignment the well-known Saidapet farm was started in 1864 and entrusted, as a "model farm," to a committee of amateur enthusiasts, who boldly undertook to conduct—

(*i*) a full trial and exhibition of the agricultural implements received from England;
(*ii*) a full trial of artificial manures;
(*iii*) an exhibition to the people of the *improved* system of agriculture.

This committee laboured on heroically at its great task till 1871, when it was dissolved and the farm passed to official control.

An era of gloom supervened. The implements and methods of Western agriculture were in ill-favour. The raiyat apparently *did* know his own business best. But manure was obviously the thing. Let manure manufactories arise in the land; give the raiyat advances to buy from them and the Agricultural Department could settle down to the collection of statistics.

But, while statistics and famine analyses were the principal concern of the department, the scientific officers worked steadily on various problems which came into prominence. Between

1895 and 1897 sugarcane in Godavari was steadily declining owing to "red rot." Nothing was done until the position became practically hopeless, but in 1901 Dr. Barber was allowed to lease land in Godavari to attempt to discover resistant varieties of cane. In this he succeeded. Again in 1898 complaints were received from the Chamber of Commerce regarding the deterioration of groundnuts. A farm was opened in 1904 for the study of groundnuts in South Arcot district and another on the West Coast to investigate the diseases of pepper, and these farms were apparently managed by revenue inspectors trained by, and working under, Mr. Benson, Deputy Director of Agriculture, a trained European expert.

Thus gradually the nucleus of a staff and an equipment was built up.

The North-Western Provinces of Agra and Oudh (now the United Provinces).—In 1874 the Lieutenant-Governor, Sir John Strachey, who had been a member of Lord Mayo's Government, established a Provincial Department of Agriculture. The new department was started on thoroughly sound lines. It took over charge of the three model farms which had formerly been managed by the district officers. The objects which the Director was instructed to keep in view were "to establish and "prove to native agriculturists the advantages to be gained "from small improvements such as they are able with the means "at their disposal to carry out, and to make experiments as to "staples and industries which it may be possible to introduce, if "new, or to familiarize and improve if already existing in the "country." Sericulture, the improvement of indigenous fibres and the manufacture of a better class of tobacco were first taken up by the new department. Mr. (now Sir Edward) Buck was the first Director and his name will go down to posterity as the pioneer of agricultural progress in India.

The Cawnpore farm—one of the oldest, if not the oldest, farm in India—was extended; a tobacco farm was started at Ghazipur, a silk farm in the Dun, and a fruit farm in the Kumaon Hills. Tobacco and sericulture failed, but marked success was obtained in the Kumaon Hills with fruit and potatoes, and the firm establishment of these industries as well

as the improvement of arboriculture stand to the credit of the young department.

The work of the United Provinces' department has always been distinguished by its practical economic character and, in the 'eighties, attention was first directed to well-boring and well-sinking, which to the present day is not the least important side of the department's activities. The reclamation of *usar* land and of ravines and the eradication of *kans* were amongst the practical problems attacked, and in the first two lines of work great success was achieved. On a reclaimed area of *usar* land at Cherat was laid the foundation of the well-known Aligarh dairy farm. Cattle-breeding and the improvement of cotton were not so successful, the lack of trained officers to conduct the work being the main cause of failure. Nevertheless the American cotton then tried was gradually acclimatised and formed the basis of the type now known as "Cawnpore American." Rapid progress was achieved with the introduction of improved cane-crushing machinery while the departmental workshops, established at Cawnpore, were another practical success.

Work in the 'nineties was much on the same lines. Improved implements had been multiplied and their distribution was carried out on a large scale. Special indigenous and foreign varieties of seeds were tested and proved on the experimental farms and seed depôts were established for their distribution; the well-boring establishment was largely increased; an agricultural school was opened at Cawnpore; and a Deputy Director of Agriculture was appointed in 1901.

The rapidly expanding work of the department had indicated the necessity for a trained staff—engineers for well-boring and sugar machinery, economic botanists for seed-selection and hybridisation and agriculturists for experimental research. The department as originally constituted had achieved considerable success and where it had failed the failure was due mainly to the want of expert guidance and continuity of effort. It had in many directions paved the way for large developments in the future and was, in a peculiar measure, ready for the expansion which the reforms of 1905 made possible.

Bengal (*including Bihar and Orissa and Assam*).—For the purposes of an historical retrospect it will be convenient to link together these four areas disregarding the administrative redistribution of recent years.

Interest in agricultural problems would appear to have awakened about 1871. A scheme was started to place "a good "man in charge of a Government estate, with a home farm of 50 "or 60 acres and a number of small, inspected and controlled "farms in the hands of raiyats, while to the raiyats in general "would be given seed, prizes and encouragement." Half the cost of this kindly and paternal scheme was met by the Government of India, and, under these orders, "model farms" were established at seven places in the province. The famine troubles of 1874 killed them in their infancy.

The history of the decade from 1870 to 1880 is one of controversy as to the utility or otherwise of an Agricultural Department. It culminated in the decision that the first step should be the education at Cirencester of one or two distinguished science graduates of the Calcutta University and the matter ended with the establishment of two State scholarships. A Director of Agriculture with three assistants trained at Cirencester was appointed in 1881 and experimental farms were started on Court-of-Wards' estates.

In 1887 it was laid down that, "if retained," the department would be concerned more with surveys and settlements than with agriculture. Even then there seem to have been some doubts, and the final judgment on the work of the department is recorded in the caustic review of 1893-94:—"The "record of ignorant and unsuccessful experiments conducted "on private estates at the instance of the department is rather "ludicrous and at the same time rather lamentable. It is per- "haps good for Government officers and zemindars to have "taken this interest in the crops and learnt a few rudimentary "lessons in cultivation and enabled themselves to share in the "feelings of agriculturists as to the vicissitudes of weather, but "it is idle to hope for any serious improvement in the agricul- "ture of the country to be effected in this way." It would appear, however, that things continued to go on much as before

till the end of the last century. The Sibpur farm, started in 1887-88, absolutely unsuitable on account of variability of soil, was the central part of the scheme, but it was abandoned in 1898.

From 1902 to 1904 the Government of Bengal were engaged upon a revision of their Agricultural Department, but as its proposals went into the melting-pot when the general scheme of Imperial expansion came to the front, they need not be described.

The Central Provinces.—The Agri-Horticultural Society of Nagpur—started in 1862—marks the commencement of agricultural development in the Central Provinces. Amongst strictly agricultural products, cotton early attracted attention. An agricultural survey of the cotton tracts was started in 1861 and Egyptian seed was distributed in 1863, but without success. Successful efforts were, however, made to establish gins and presses in the cotton tract to provide baled cotton for export by the Nagpur-Bombay Railway, which was approaching completion. In 1866-67 a Cotton Commissioner was appointed for the Central Provinces and Berar. Attempts to introduce exotics failed and *Hinghanghat*—the local *Bani*—was found the best type and was distributed throughout the province. More success was achieved on the commercial side, in the cleaning and handling of the cotton, the multiplication of baling presses and gins and the arrangements for exports to, and sales at, Bombay.

After various attempts to introduce *Hinghanghat* experiments were concentrated at Nagpur, but the yearly reports of the farm up to 1882-83 are a continuous record of failure. There is nothing on record to show for what reasons the various experiments were tried. The causes of failure were similar to those found in the early work of other provinces. The natural surroundings and methods of cultivation of exotic varieties were not understood or taken into account and there was an entire absence of expert supervision.

In 1882-83 a new site for the farm was selected and experiments of a more practical kind were started. But these were not continuous, and no results of real agricultural value were obtained. In 1890-91 the record of experiments conducted at the Nagpur farm was examined and a fresh scheme drawn up, care being taken to secure equality of conditions in the areas intended for each separate experiment. The scheme was again

remodelled in 1893-94 on the advice of the Agricultural Chemist to the Government of India and work continued on these lines until the reorganisation of the department in 1904.

Its early labours had not, however, been in vain. The department, at all events, was a centre for the dissemination of agricultural knowledge and for agricultural education among Government officials. A large amount of useful knowledge regarding the relative values and outturns of local crops, their methods of cultivation and how these were conditioned by local differences of soil and climate had been obtained, and this knowledge, widely disseminated among the higher ranks of Government officials, was found to be of great value when the time came to discuss the recommendations of the Irrigation Commission. In addition, a farm staff had been trained with some idea of the necessity of careful and conscientious observation and record. The reasonable efficiency of cultivation secured on the farm rendered it possible for the department to demonstrate, with a confidence never possessed before, such simple improvements as they had tested and proved, and the foundation was laid of the present system of demonstration, by the deputation of labourers from the Nagpur farm to demonstrate the line cultivation of cotton and *juari* in the black soil tracts of Chhattisgarh.

Amongst direct improvements the introduction of the Meagher system of sewage disposal, the use of sulphate of copper for the disinfection of *juari* seed, the advantages of winnowers and ploughs of the modern type represented real and useful additions to local agricultural knowledge.

Punjab.—There is nothing on record to show that the Punjab Government interested itself to any extent in the development of agriculture till 1881, when the Famine Commission Report was published. It is clear that, when a Director of Agriculture was appointed, he was mainly concerned with statistics and the organization of a subordinate revenue establishment. For the rest a number of disconnected agricultural experiments were carried out on a small scale, such as trials of exotic varieties of cotton, wheat and maize—practically all of which ended in failure. In 1901, 56 acres of land at Lyallpur were turned into a farm and in 1902 three agricultural assist-

ants trained at Cawnpore started work there, but with little success. The Punjab therefore started the new era with an almost clean slate and with few of the mistakes of a misdirected past to correct.

Burma.—While the scientific study of agriculture has only recently been taken up its improvement had been attempted by the Government of Burma soon after the occupation of the province. This took the line of protective embankments, and the material wealth of the delta is largely due to the extensive system of these works. Government seems also to have considered that both the crops grown and the methods of cultivation were susceptible of improvement and, for several years after the annexation, it endeavoured to introduce improved varieties of paddy—for instance Carolina—and agricultural implements of a western type. None of the exotic varieties of paddy seem to have done well in Pegu, though there is some reason to believe that a Carolina or other imported variety is the ancestor of the present Moulmein *kaukkyi* paddy, which has more than a local reputation. A few unsuccessful experiments with implements, and some work on tobacco manufacture, carried out by Mr. Cabaniss—the Assistant Director—are instances of the work done between 1882 and 1887, when the department was under a Director.

After the annexation of Upper Burma agriculture became the care of a Director of Land Records and Agriculture—an arrangement which held good till 1905. During these eighteen years the time and attention devoted to agriculture was very small; there was no expert staff, no experimental farms. Some half-dozen gardens were maintained at outlying frontier posts and seeds, if asked for, were supplied to district officers. Still, even under these conditions, some definite results were obtained. The distribution of Havana tobacco seed has established a superior grade of tobacco in Maubin; the introduction of groundnut has revolutionized the agriculture of the dry zone and saved that tract from the recurring danger of scarcity; while by means of the experimental gardens wheat and potatoes have been established in the Shan States and Chin Hills. The early efforts of the department cannot therefore be considered to have been altogether fruitless.

Summary.—Such is the record of achievement in the provinces up to the beginning of the 20th century. Viewed in the light of more recent developments it may not have amounted to much. It could hardly in the circumstances be expected that it would. The principles of agricultural research were, at that stage, but vaguely understood even in England. The vast problems of Indian agriculture were being attacked by a mere handful of isolated workers with no trained staff and no organisation to give effect to their recommendations. The general impression one gets from the record of these early efforts is that men were groping in the dark. The problems were so numerous and overwhelming that they did not know where to begin.

Until an adequate trained staff became available the early policy, which laid special stress on agricultural statistics and a proper appreciation of local conditions, was, in the circumstances of the case, probably the correct one. A so-called Agricultural Department which contained scarcely any scientific officers could at least manage this and there were obvious advantages in collecting information which an expert staff could utilise when it arrived.

But from the failures which followed many amateur efforts some useful lessons were learned. It was found that, in many cases, a more hopeful line was the improvement of indigenous varieties by selection rather than the introduction of exotics. If exotics were to succeed the information at least had been gained that the effects of change of environment were matters of first importance.

Where environment was suitable a few notable successes in the introduction of new crops were achieved: groundnut in Burma; potatoes and fruits in the Kumaon Hills; American cotton in the United Provinces. And the lesson also had been learned that the East had much to teach the West and that it was wrong to assume that the cultivator had not sound reasons for his practice. At any rate the fallacy of foisting western ideas on him, without reference to local conditions, was fully exposed and the fact emphasised that the true line of development was the improvement of indigenous methods.

CHAPTER III.

The Establishment of the Agricultural Research Institute at Pusa and the Development of Provincial Departments.

Rapid developments followed the appointment of the Inspector-General of Agriculture in 1901. A number of scientific workers had been recruited. But scientific workers are handicapped if they have not adequate laboratories: and their discoveries are of little practical value if they cannot be demonstrated on a farm. It was therefore necessary to provide both for the staff of the Imperial department.

Very opportunely, early in this century, a proposal emanated from the Government of Bengal to utilise a large Government estate at Pusa in the Darbhanga district of Bihar as a provincial research station and college. The Government of India considered that this site might suit their needs and, with the full concurrence of the Government of Bengal, the estate was taken over for the purposes of an agricultural research institute, an experimental farm and an agricultural college. At this juncture a generous donation of £20,000, to which £10,000 was subsequently added, was made to the Viceroy by Mr. Henry Phipps of Chicago. This gift was fortunately tendered when the extensive development of agricultural departments was under consideration and Lord Curzon decided to devote the greater portion of it to the equipment of the new research institute.

It was intended that the farm should serve as a model for similar institutions in the provinces. On it would be initiated lines of enquiry which would be tried before being recommended for trial under local conditions on provincial experimental farms. Varieties of crops would be tested and improved; the seed of improved varieties would be grown and distributed. It would test under different conditions and more highly skilled supervision results reported from provincial farms, and in particular would secure continuity for any experiments which

might have been tried, and then discontinued, on a provincial farm. Finally, it would serve for the practical training of students at the Imperial Agricultural College, and provide for field experiments connected with research work.

The programme was an ambitious one and has not been fully worked up to. The capacity of the farm is limited by the conditions of climate and soil. But it has done much good work already in producing improved seed in large quantities and has carried out a considerable number of important experiments of general application, while experiments with cattle and sheep have also been undertaken.

The Research Institute challenges comparison with any similar institute in the East and is fully equipped with laboratories, museums, herbaria, library and lecture rooms. Pusa is six miles from Waini on the Bengal and North-Western Railway and is easily reached by train from Calcutta. It attracts annually an increasing number of visitors. No visitor to India who is interested in scientific agriculture, should leave the country without seeing Pusa. From the Institute an increasing mass of work is being turned out. The staff consists (in addition to the director, who is also Agricultural Adviser to the Government of India) of an agricultural chemist, a mycologist, an economic botanist, an agricultural bacteriologist, an economic entomologist, a pathological entomologist and an agriculturist who is in charge of the farm.

The idea of attaching to the research station an agricultural college really grew out of the necessities of Bengal. The agricultural college at Sibpur had not been successful, and the Bengal scheme for the utilisation of Pusa contemplated the transfer of this college to Pusa. When, therefore, the Pusa scheme was taken over by the Government of India, it appeared essential that Pusa should include a college to provide for Bengal, even though admission should not be confined to that province. This, though one of the objects, was not the chief reason for the establishment of a Central Imperial College. It was hoped that it would serve as a model for, and raise the standard of, agricultural colleges in other provinces, and provide for a more complete and efficient agricultural education

than was then possible in any of the existing institutions as it was necessary to provide for the extension and completion of provincial educational facilities. It was, moreover, necessary to arrange for the training of the teachers of the future and of specialists in the various branches of science connected with agriculture, who up till then had to be recruited in Europe.

On the educational side the aim at the outset was twofold. In the first place it was intended to train students who could not attend any of the provincial colleges or schools and in the second place to provide a higher course of training to those who had studied at provincial institutions and who desired to qualify themselves for professorships, research work or for posts requiring special scientific attainments.

It was fortunate for the institute as a centre of research that the rapid extension of agricultural colleges in the provinces rendered it unnecessary for Pusa to provide for the first class of students, while the number of students qualified to avail themselves of the second part of the scheme was, in the early stages, small.

The position now is that no regular course of instruction is given at the Institute, except short courses in special subjects. As regards post-graduate work or work in special subjects, selected graduates from provincial colleges receive instruction in the laboratories from members of the expert staff—an arrangement which is in every way satisfactory. The time of the experts is not wasted on the drudgery of formal teaching, while the graduate who has completed his general agricultural education can specialise in one branch under the personal supervision of an expert in his subject and with every advantage in the way of laboratories and libraries.

Pusa may, of course, ultimately become the training ground for Indian students who desire to enter the superior service—the Indian Agricultural Service—and it may perhaps be decided that this, and not a British qualification, should be the prescribed standard for admission. Should that stage be reached considerable additions to the staff would certainly be necessary if there was to be no interference with research, which now,

and for many years to come, must be the principal concern of the Institute.

Apart from the establishment of a central research institute with an Imperial staff, the development of provincial agencies was seriously taken in hand. An immense stimulus both to Imperial and provincial development was given when, in the financial statement of 1905-06, it was announced that a sum of 20 lakhs (subsequently raised to 24 lakhs) would annually be available for the improvement of agriculture. Without this grant the development which has taken place during the past ten years would have been impossible. Considerable discussions as to the best method of utilising the funds which had become available took place. That a rigorous policy of agricultural improvement should be pursued was accepted, but at the same time the necessity for caution was emphasised.

With this annual grant it was contemplated to establish, in each important province, an agricultural college and research station, adequately equipped with laboratories and class rooms, to which would be attached a farm of suitable size. The superior staff proposed at each of these provincial institutions was an expert agriculturist, an economic botanist, an agricultural chemist, an entomologist and a mycologist, one of the members of this staff discharging the duties of principal of the college. The staff was to combine teaching with research. It was held that research would ordinarily be more active and better sustained if associated with lecturing as this would check any tendency to the investigation of problems unlikely to lead to practical results. To enable the experts to carry on research and to tour an adequate number of assistants and demonstrators were to be provided. They would also assist in the teaching so that the time of experts might not be wasted in elementary tuition.

To direct the work civilian directors were appointed in all the larger provinces. But the expansion of staff was not as rapid as anticipated. The view was taken that the backbone of the scheme was the *educational* aspect, and the establishment sanctioned for each of the provinces was limited to an all-round agriculturist as principal of the college, an agricultural

botanist and an agricultural chemist and, in the words of Lord Morley, the creation of provincial colleges having the above-mentioned staffs would remain a primary feature of the scheme. Colleges were accordingly reorganised or started at Poona, Cawnpore, Sabour, Nagpur, Lyallpur and Coimbatore.

However desirable the establishment of colleges may be, it is clear that, apart from teaching, there is an enormous amount of experiment and research to be done if agriculture is to be improved. Officers are necessary for the superintendence of farms for experiment and for the supervision of demonstration and seed distribution. The duties of such officers cannot be carried out satisfactorily by experts who are tied to their headquarters by educational duties. To meet this want deputy directors were appointed. The importance of a staff of entomologists and mycologists for the larger provinces was again emphasised. It was pointed out that the annual losses from wheat-rust amounted to two millions sterling, while from bollworm, in the Punjab, there had been a loss, in one year, of one and a half millions sterling. The addition of entomologists and mycologists was however considered by the Secretary of State to be premature as it was thought that the Imperial Entomologist and Mycologist could undertake important investigations for the provinces and could train Indian assistants.

Madras is the only province which possesses an entomologist and a mycologist and these have not been trained as contemplated but have been recruited from England.

The expansion of provincial establishments has, in recent years, been very rapid and, at the present time, there are employed twenty-nine agriculturists, nine agricultural chemists, eight economic botanists, three agricultural engineers, one entomologist and one mycologist. In addition special appointments have been made, such as the Government sugarcane expert, the sugar engineer, the fibre expert, the Imperial cotton specialist and the scientific officer for planting industries in Southern India.

CHAPTER IV.

The Organisation and Work of Provincial Departments of Agriculture.

In each province agricultural and veterinary work are under the control of a Director of Agriculture. Up to the present this officer has generally been selected from the Indian Civil Service. In the early days of the department an officer familiar with the language and agriculture of the country can probably best discharge the duties of Director, and as the initial work is largely administrative, an officer from this service with administrative and settlement experience is perhaps best qualified to direct operations. It is not improbable however that these appointments may ultimately be held by members of the Indian Agricultural Service.

In provinces in which there are agricultural colleges, the scientific officers are stationed at the college and have their laboratories, herbaria, etc., there. Attached to the college is a farm, used for training the students in practical agriculture, for the demonstration of collections of the cultivated plants of the locality and for a certain amount of experimental work. Here also are the botanical areas where the economic botanist carries out his work of crop selection and crop improvement. When sufficient progress has been made these crops are tested on a field scale with seed produced on the college farm. The agricultural chemist also has an area where he conducts manurial and other experiments and tests the results of his laboratory investigation in the field. Here all the botanical and chemical work for the Deputy Directors is done.

Deputy Directors, each in charge of a circle, are posted at different stations and, aided by a staff of Indian assistants, control the experimental, demonstration and seed farms.

This in broad lines is the constitution of a provincial department.

The problem which it sets itself is the improvement of Indian agriculture. The basis of all progress is research. Whatever the problem undertaken, this is the first process. The results of research are then tested on a field scale. The experiment proved, the stage of demonstration is reached. These processes apply, whether the subject be chemical, agricultural or botanical. Finally, there is, in the case of seed, distribution from seed farms, where the improved seed is multiplied. There is thus the laboratory, or the small research plot which is the agriculturists' laboratory; the field test, on a small scale, still under strict supervision; the demonstration farm, where the improvement can be brought home to the cultivator; and the seed farm, where the improved seed is produced and distributed.

This all seems very simple, but the difficulties in agricultural work in India are really very great. Let us proceed to consider a few of them.

To see how these difficulties arise we must go back to the days when railways were few and the means of communication indifferent. We find the self-contained village growing its food crop for its food, its fibre crop for its clothing: content with little and practically independent of the outside world. In his village the cultivator ground the grain into flour: in his house the fibre was woven into cloth. The food crop he grew, say wheat, was of the quality he wanted: at least it had to be: if it was not he could get nothing better. The village taste set the standard of quality: if the quality deteriorated there was no means of improving it. To this village, in the course of his tours, comes one of our amateur enthusiasts. He sees the village crop; he talks to the people; he finds that their outturn of wheat or cotton is low. He remembers some higher-yielding exotic and he sends them seed. It is tried but gets mixed with the local varieties and, in addition, cross-fertilisation goes on. But, so far as the village is concerned, it is wheat or cotton: they notice no difference. And there are no buyers from outside to tell them what is good or bad. Or perhaps they have been advised to try some new crop from some other part of the district. It is grown and proves a useful addition to the

village dietary. The village is still self-contained : the requirements of the outside world do not interest or concern it.

But, suddenly, the whole outlook is altered by the opening of a railway which passes hard by the village. A stranger arrives who takes an interest in their crops and wants to buy, paying rupees for what he takes. The villagers go further afield. They visit a large neighbouring town. They find that all sorts of things can be bought if only they have the money. The stranger, ready to buy their produce, is a welcome visitor and they increase their sowings and so have a surplus for sale.

For two or three seasons the buyer comes and then his visits cease; or, if he comes, he pays a lower price than he did because the grain is not of even quality but is mixed or discoloured and is not what the market wants. The nice discrimination of the market has begun to affect the little village. The villagers meet the situation with equanimity : there is nothing else to be done : in any case they do not know what to do. Few of them connect their trade misfortunes with the kindly intention of the visitor who sent them the foreign seed. But the ground has been prepared for the lessons which the Agricultural Department may, in course of time, have to teach.

When the officers of the Agricultural Department arrived in India they found, in nearly every crop they studied, an extraordinary number of mixtures. The cultivator whose interests were limited to his village saw no harm in this. But when the demands of outside trade set a standard the disadvantage was brought home to him and was reflected in reduced prices.

Before any improvement can be effected it is necessary to make a careful study of the crops and varieties of crops that actually exist. Innumerable varieties and deteriorated samples are found and it is first necessary to determine by selection what is the best. This is done by an examination of the plants growing in the field. What appears best are selected and grown side by side. Their characters and outturn are studied and, when the superiority of one or two types is demonstrated and proved, the seed is multiplied and distributed.

This is the method of *improvement by selection*. It is an admirable method for India as there can be little doubt that there are already in the country numerous crops of high quality if they are grown pure to the best type. This quality not only meets the local taste, but also the export market.

There are two problems to be solved. In the case of crops the bulk of which form the food of the people and are consumed locally, improvement without losing those qualities which meet the local taste, is the first problem. But it may be that there is an export demand. If the requirements of the local taste and export trade can be made to agree then the problem is enormously simplified. It seems unlikely that in many cases they will differ—at any rate in food crops. The local taste can easily adapt itself to the quality which commands money as an article of export. This point has already been proved in the case of wheat and it is improbable that it will be otherwise in the case of rice. The problem therefore is to raise a crop of a quality which meets the demands of the export trade and, at the same time, satisfies the local taste. In the case of food crops improvement by selection from existing varieties seems the most hopeful line of work.

It frequently happens, however, that, although there is an export demand for the local variety, that variety is still capable of improvement both in quality and yield, without upsetting its general utility. Indian wheat is a case in point. The Howards have shown that so far as grain is concerned India already possesses wheats of a very high order which suit both the local taste and the export market. But many varieties are liable to rust; the straw is weak and the crop falls before the high hot winds of March with consequent shedding and loss of grain. Or again, in the case of tobacco, to suit the demands of the market for cigarettes it is necessary to obtain light burning and light coloured tobaccos. If these qualities can be given to the Indian tobaccos the gain to the country would be immense. Fortunately this is now possible by the process of *improvement by cross-breeding or hybridisation*. This is the second great method of improving plants.

The process of *cross-breeding* and *hybridisation* has been completely revolutionised by the discovery of Mendel's work on hybridisation. His theory, originally given publicity in a paper read before the Natural History Society of Brünn, eclipsed perhaps by the work of Darwin on the "Origin of Species," remained unnoticed for nearly forty years. Its rediscovery has completely altered the lines of plant improvement by hybridisation. Under the old methods crossing was purely accidental. One never could tell what one would get. Out of the resulting crosses one could pick out what seemed to approximate most closely to what was wanted; the remainder would be thrown away. There was no guarantee that the cross would breed true in the second generation.

As frequent references will subsequently be made to work on Mendelian lines I shall give a simple description of what it means.

The law of Mendel has made it possible to obtain practical and certain results from plant breeding in a comparatively short time. By means of this method it is possible to create new plants combining the desirable qualities of both parents.

Hybridisation, like selection, is only possible after the separation of mixed plants into their ultimate constituents. Most of the Mendelian work in India has been done on wheat and if we take the concrete example the method can perhaps best be understood. In wheat breeding it is desirable to use for crossing only pure lines, *i.e.*, the progeny of single plants. It frequently happens, when a wheat mixture has been resolved into its constituents, that all the desirable qualities are not found in any one wheat. Thus some wheats, characterised by high-yielding capacity, may be defective either in quality, in resistance to rust or in strength of straw. Others may possess these characters but give poor yields. It is in producing new wheats, perfect in all respects, that hybridisation as a method of improvement has its value.

Mendelism implies a complete study of the inheritance of characters in which each character is considered to act as a unit or a group of units. Thus, in wheat, grain-yielding power,

strength of straw and resistance to rust are characters which act as units and pass over as a whole to the various hybrid generations. For example, when a rust-liable and rust-resistant wheat are crossed, the plants of the first hybrid generation are all rust-liable like one of the parents. In the second generation, however, *splitting* takes place; some of the crosses are still rusty: others (a lesser number) are rust-resistant. The latter, in succeeding generations, breed true to a rust-resistant character. It is possible, therefore, by crossing to introduce the character of rust-resistance into a wheat wanting in this quality. Similarly such characters as high grain quality, strength of straw, etc., can be introduced into a wheat defective in these characters. These are the lines on which the Pusa experiments on wheat have been carried out. High-yielding wheats of poor quality have been crossed with wheats of high quality but poor yield. In the third and fourth generations of the progeny of these crosses it has been possible to select and fix wheats which possess the high-yielding power of one parent with the high grain quality of the other.

Mendelian work is slow and requires an infinity of patience. The difficulty is to isolate plants which are an improvement, that is, which contain within themselves a large number of desirable characters. The successful Mendelian worker must have a strong power of discrimination and the courage to abandon, ruthlessly, what does not suit his purpose.

The question of the supply of *pure seed* is one of the most important in India. Types of good crops exist, but, by neglect and lack of appreciation of the importance of the problem, they have, accidentally and by natural cross fertilisation, become hopelessly mixed. The isolation and testing of pure lines, produced from a typical selection of a single plant, must be the basis either for improvement by selection or by hybridisation. The former work can be efficiently done by Deputy Directors, who receive a botanical training in their agricultural course: the botanists can undertake improvement on both lines. All the characteristics must be studied—botanical, field and physiological. Any other method of selection,

such as choosing good-looking plants out of a field crop, is absolutely useless and waste of time.

Why, it may be asked, should such importance be attached to seed selection as the primary duty of an Agricultural Department? Surely an expensive department is not required for this.

The answer is that it is useless to attempt to improve agricultural practice if the seed is not good and the best obtainable. The seed is the rock on which the house of agriculture must be built. The vast majority of the cultivators of India cannot select this seed themselves. There are practically no seedsmen in India who deal with the seed of the main field crops. There is little likelihood of their appearance for some time to come and the agricultural departments must do the work, isolating the pure types on central control stations and multiplying the seed on their own seed farms, or, as is done, in England, through selected farmers.

With a task of this magnitude I would place, as the second great problem of Indian agriculture, the organisation of an agency to disseminate this seed. This must be done by the multiplication of seed farms in charge either of the department itself, of co-operative societies or of private individuals, but all, for the present at all events, controlled from the central control station. There is reason to hope that, ultimately, with the appreciation of the advantages of good seed, cultivators will themselves adequately control and protect the quality of their seed. But the time is not yet.

Improvements in the methods of agriculture; manures; implements—these are all lines of development which suggest themselves. With regard to the first, we must remember that the existing agricultural practice of India is based on the accumulated experience of years. There is no school like that of experience and we must be very sure of our ground before we recommend anything. It is only in the rarest cases that we can say that that practice is wrong. We can teach the Indian cultivator little about rotation of crops, although we may know the reason while he does not. But slight improvements of prac-

tice may be possible. These should be very cautiously recommended and only after they have been thoroughly proved and demonstrated. The Indian raiyat probably has very good reasons for shallow ploughing in certain tracts. Deep ploughing must be proved to have advantages before we recommend it. Our greater knowledge of agricultural science may enable us to discover reasons and, with wider experience, we may bring to bear on Indian agricultural practice the discoveries of modern science the advantages of which might otherwise be denied to this country. But we must exercise judgment and caution in our application of them to Indian conditions.

We have seen that the introduction of European machinery has always figured prominently in the efforts of the amateur agricultural reformer. Much success has, undoubtedly, been obtained in the introduction of grain-winnowers, cane-crushing machinery, etc. But in recommending the introduction of reaping machines or heavy English ploughs caution is necessary. Reaping machines may be useful on large estates where labour is scarce, but the whole rural economy of a tract where population is dense may be upset by their use. A large amount of cheap labour which ordinarily does the reaping is thrown out of employment: the gleaners lose their recognised perquisites. In the case of heavy ploughs, the advisability of deep ploughing has first to be proved. In both cases the capacity of the available cattle and the difficulty of replacing broken spare parts and of carrying out repairs are serious obstacles to the introduction of foreign machinery. As in the case of plants, the improvement of the local material which the cultivator can himself make and repair and which his cattle can draw, seems the more hopeful line of improvement.

The question of manures is also a difficult one in India. Farmyard manure there is, but not in quantities to admit of generous application. Artificial manures are expensive. Even if their application produces a largely increased crop, it is the present expenditure and not the future profit that the cultivator considers, and until artificial manures can be economically manufactured in India it seems doubtful whether they can be introduced on any considerable scale.

In short, the problem of bringing the conclusions of science to the aid of the ordinary cultivator of India is a very complex one. There are the limitations of his conservatism, of his scant education, his small holding and his restricted means.

In India the officers of the Agricultural Department must take the place both of the intelligent landlord of Europe and of the seedsman. All the experimental work must be done by the department and its results offered for application in a cheap and simple way. The cultivator is not concerned with the process of discovery. The concrete results of chemical, botanical and bacteriological research must be presented to him in a form which he can readily apply. The cultivator wants none of the reasons for it or the process by which it is arrived at.

It is obvious that if results of practical value are to be obtained the agricultural worker must have a thorough knowledge of Indian agriculture and a sympathetic feeling towards the people. Above all, he must " go slow."

CHAPTER V.

Cotton.

We may now proceed to examine what the department of agriculture has done, or is doing, for the improvement of the crops of the country.

Convention has decreed that civilised man shall be clothed: climatic considerations indicate, for large parts of India, light raiment: Nature has supplied cotton.

We have seen that in Bombay, the United Provinces and the Central Provinces attempts to improve this crop had from the earliest days been made and that these took the line of the introduction of exotics. But no allowance was made for differences of climate and environment and no systematic agricultural experiments were carried out to ascertain under what conditions of sowing and cultivation these new varieties would succeed. Practically all the experiments, therefore, ended in failure. But "the little seed falling by the wayside" has in some cases borne fruit. The present American cotton of the Punjab was, probably, established by a general distribution of seed made in 1903 without much attention to its possible success or failure. This seed, as might be expected, became hopelessly mixed with the local varieties and the problem now is to isolate the original pure American strain, and to develop it, if, on examination, it is found to be worth keeping. In many cases it is doubtful whether exotics introduced in the early days are now of any value, and deterioration has been so great that in some provinces a wholesale campaign to eradicate them would be justified. They have become the "tares" amongst the cotton.

In the United Provinces an early promiscuous distribution of exotics laid the basis of the present "Cawnpore American." In an earlier chapter we have seen what was attempted in Bombay where the establishment of "Dharwar American" is the only achievement that can be claimed. The verdict passed

by Mr. Mollison on Bombay is generally applicable to these early experiments. He was of opinion that exotic cottons were unsuited to the conditions of Indian agriculture. An indigenous variety found suitable in one district might prove unsuitable in another and the only hope of improvement lay in taking the varieties that were found in general cultivation and endeavouring to improve them by steady and continuous seed selection.

Early workers were largely in the dark. No allowance was made for changes of environment or climate. Economic botany was in its infancy and plant selection, hybridisation and cross-breeding were only believed in by a few specialists. It was not until a trained staff applied the methods and technique of modern science to the agriculture of the country that any real progress on correct lines could be expected. But if little or no success was achieved on the agricultural side, solid results were obtained in some provinces in the handling of cotton and in arranging for its marketing and disposal.

Of the total cultivated area of India proper over 6 per cent. is under cotton and within the last twenty years the area has increased by over 67 per cent. The local demand has increased by as much as 80 per cent., it has been estimated, during the last sixteen years and Japan, China, Africa and Central Asia import Indian cotton in increasing quantities. The cotton crop of 1913-14 was estimated at over 5 million bales. Of this crop nearly 3 million bales, worth more than 27 million pounds sterling, were exported. Japan is our best customer and took more Indian cotton than Germany, Belgium, Italy, Austria Hungary, France and the United Kingdom combined, and these countries are, in the order stated, after Japan, our largest buyers. Japan takes nearly twelve times as much as the United Kingdom and, of the crop of 1913-14, absorbed 1,348,000 bales.

On the average about 44 per cent. of the whole crop is retained for local manufacture and consumption and, in addition, India imports cotton and cotton goods to the value of over 44 million pounds. From its numerous mills India exports enormous quantities of cotton yarn, woven goods and piece goods valued, in 1913-14, at over eight million pounds,

In Madras during the last twenty years the area under cotton has increased by a million acres: in Bombay by nearly a million and a-half acres: in the Punjab by 900,000 acres: in the Central Provinces and Berar by over a million and a-half acres. The smaller provinces show a steady proportionate expansion, while the Native States show an increase of nearly a million and a-half acres. The Indian Empire has thus responded to the increase in the internal and external demand.

What has the Department of Agriculture been doing for this crop which brings so much money into India?

The problem of the improvement of Indian cotton falls under two heads—the first, the selection of the best pure types from existing varieties, the maintenance of these types and the increase of the yield by better cultivation; the second, the introduction of exotics or the production of hybrids. The first is concerned principally with the improvement of short-stapled cottons, for which India has a reputation, and it is to this that efforts have for the most part been directed; the second is an attempt to meet the demands of Lancashire for long-stapled cottons.

But whether the problem is the replacement of a mixed crop by a selected indigenous type or the introduction of exotics many difficulties have to be overcome. The variety must be fixed so as to breed true from seed. Large quantities of seed must be available so as entirely to replace the old variety, for, if this is not done, the new variety may be cross-fertilised from a field of the old in the neighbourhood. It must be ginned separately or it will become mixed with other cotton at the public ginneries. Further, when the improved type has been produced, it requires the encouragement and preferential treatment of the trade to establish it.

Without an efficient organisation to attend to all these details, the chances of success are small unless the new variety can be confined to a compact area or can be introduced into a fresh tract where no other variety of cotton is cultivated.

We have said that efforts have been for the most part devoted to the indigenous crop. When agricultural workers first examined the existing crops, they found admixtures almost

everywhere. A survey of the indigenous cottons of India had been made by the Imperial Cotton Specialist and, aided by this, provincial officers proceeded to isolate and maintain pure types, to improve their outturn and quality by selection and to introduce the improved plant into general cultivation.

On these lines rapid success was achieved. Soon Bombay could claim a selected variety of Broach cotton which yielded 500 to 600lb per acre with a ginning percentage of 32·5 against 450lb per acre with a ginning percentage of 31·9 obtained from unselected seed. In the Central Provinces a white-flowered cotton, *Roseum*, was selected as the best local variety and was developed for lint percentage. No. 1 Roseum yields a percentage of from 39 to 41 of lint. This has been developed and by an admirable network of seed farms and agricultural unions—all controlled by the department—no less than 1,760,000lb of seed have been produced, which sells at more than twice the price of unselected bazaar seed.

In the United Provinces, by similar methods of selection, " Aligarh white-flowered " cotton, which gives a ginning percentage of about 40 and yields well, has been established and this cotton commands a premium of from 12 annas to Re. 1-4-0 per maund. Selected cultivators grow the seed, which is specially ginned under the supervision of the department, and co-operative societies have also been utilised in the work.

The efforts of the Madras department to isolate pure Karunganni cotton and to distribute pure seed has met with the cordial approval of the trade and this seed sells at 40 per cent. above the price of bazaar seed. A variety has been produced giving a 7 per cent. increase of lint while, by selection, another staple has been evolved which will spin up to forties. Similar work has been done at Nandyal, and the local trade are so impressed with the excellent results obtained that they have urged the department to improve by selection local varieties district by district.

Simultaneously with the improvement of the indigenous plant, the possibility of introducing superior exotic cottons has not been lost sight of. In the United Provinces the hybridisation and crossing work of Martin Leake, which is being con-

ducted on Mendelian lines, may have far-reaching results, but it is too early to describe these experiments in detail. Egyptian and Upland American cottons have been introduced in Sind, the latter with most prospect of success. In Bombay, the Punjab and the United Provinces, Americans have been established, but their extension has been retarded by the difficulty of finding a market. This, however, will be overcome as the grade is established. In the Central Provinces a type of Upland Georgian known as *buri* has given good results. The maintenance of these new varieties, true to type, is one of the problems before the department.

The greatest achievement, however, in exotics is the introduction of Cambodia in Madras, and chiefly to Mr. A. Steel of Messrs. Harvey & Co. is to be ascribed the credit. Seed was obtained from Pondicherry in 1904 : the correct method of cultivation and the conditions under which it would thrive were worked out by the Department of Agriculture. It was at once a success. The trade co-operated : the cotton was boomed and within seven years the outturn had risen to 45,000 bales. The lint was better and the ginning percentage higher than that of any indigenous variety and it could be cultivated with considerable profit on lands unsuited to Indian cotton. Valued at Rs. 180 per acre it supplanted crops which yielded only some Rs. 30. The inevitable boom followed and with it adulteration. The goose that laid the golden egg was killed. Dealers mixed it with local cotton and tried to pass off the mixture as genuine Cambodia. Raiyats grew it on unsuitable land and the staple deteriorated. This was mixed with good Cambodia and palmed off on the buyer. The crop fell under suspicion : a premium price was no longer given. The Madras department will have much to do in re-establishing it on its old footing.

The rapid establishment of Cambodia cotton was one of the greatest achievements of the new department. Had it been discovered before an organised department existed it would have been distributed indiscriminately to up-country district officers and would probably have failed as its habits were not known. But its success has been its undoing : it has got completely out of hand. While, therefore, it marks a great

achievement it indicates also a great limitation and emphasises the necessity for a rapid increase of staff if such successes are to be kept in check.

As regards the improvement of agricultural practice, experiments in cultivation, in crop rotation and on manures are being carried out on experimental farms and the results, when proved, are being introduced into general practice. The greatest care is being devoted to the production, maintenance and distribution of pure seed. Seed farms are being rapidly multiplied and it may confidently be asserted that in localities where cotton is a crop of importance as much attention as is possible is being devoted to it consistent with the legitimate demands of the other great staples.

There is no branch of their activities in which the Agricultural Departments benefit more from the healthy stimulus of friendly criticism than in cotton. Some would have them devote all their energies to cotton : some would have only long-staple cotton to the exclusion of the indigenous short-stapled varieties. Is our present policy of dividing our attention the right one?

As to the first suggestion—if we consider the relative importance of cotton among Indian crops, it would clearly be wrong to devote our undivided attention to this crop to the detriment of others of equal or greater importance. But, as our staff of workers increases, cotton and its problems will engage us more and more.

Then there are those who would have us develop only long-staple cottons. Whatever the quality and staple of Indian cotton may be, there is a strong and increasing demand for it, and it is merely a question of economic expediency whether it would be politic to interfere drastically with the present state of things. Taking everything into consideration it would seem that our experts are working on right lines in attempting to bring the indigenous crop to its fullest possible perfection. Whether India will ever be able to produce on a large scale the long-stapled cottons required by Lancashire is a difficult question. Exotics require a far more careful preparation of the soil than the cultivators consider sufficient for the varieties

which they now grow. The plants are more delicate and are more easily affected by adverse conditions and greater care has to be exercised in picking and preparation for market.

At present there is a strong and increasing demand for the coarse cottons spinning under twenties, for the production of which India is particularly suited. So long as this demand continues it would be difficult to persuade the cultivator to abandon their cultivation. Nor would it be wise to sacrifice a sure and certain market for a fluctuating and speculative one. India is now predominant in the market for short-stapled cottons, which, as the statistics show, is a considerable one, and while such a market lasts the Indian cultivator could not be persuaded to give it up. The small cultivator requires and is content with little and, so long as he can get the necessary minimum without undue exertion, he is not likely, willingly at all events, to undertake more laborious cultivation unless the advantages are beyond doubt.

At the same time the duty of India in the matter of the production of a certain amount of long-stapled cotton has not been lost sight of, and efforts are being made to introduce it where possible.

The policy which is being pursued may briefly be summarized. In view of the well-established and increasing demand for the indigenous cottons of India the first concern of the department is the improvement of these in quantity and staple by careful selection, seed-production and seed-distribution. Attention is being devoted to the improvement of the methods of cultivation and to the marketing of the produce in a cleaner, drier and more even condition. But in the latter case success must largely depend on a discriminative preference on the part of purchasers, seeing that if a cultivator can get the same price for dirty cotton as for clean, he is not likely to worry himself about the condition in which his crop reaches the market. Simultaneously, in all cotton-growing provinces of importance, efforts are being made to introduce superior long-stapled exotics, especially into tracts where cotton cultivation is being introduced for the first time. Such efforts can only succeed if it be found that the yield per acre is as good as, or better than, that of the

indigenous varieties and if the additional price obtained will compensate the cultivator for the extra labour involved. Insistence on these two conditions is only natural, for human nature demands the maximum of return for the minimum of effort. If, then, the trade insists on getting long-stapled cotton they must provide the necessary stimulus by the offer of better prices.

CHAPTER VI.

Wheat.

Wheat is the main food staple of the people of Upper India and it is, therefore, in the Punjab and the United Provinces that the crop is most important. Nearly half the cultivated area of the North-West Frontier Province is also under this crop and it is of considerable importance in the Central Provinces. About 10 per cent. of the total cultivated area of India is under wheat and about 15 per cent. of the total area of cultivation in Native States. The expansion of cultivation has been very marked in recent years. In five years there has been an all-over increase of about $8\frac{3}{4}$ million acres, while this year owing to special causes, there has been a further increase of no less than 6 million acres.

As wheat is the favourite food of a large part of the population, the amount of the crop retained in the country is considerable and amounts to from 80 to 90 per cent. of the total. In a commodity, however, like wheat, the market for which is a world market, influenced by the world supply and demand, as also by the local harvest and local requirements, no fixed percentage of the crop is exported and violent fluctuation must necessarily occur. Thus in 1904-05 exports amounted to well over 2,000,000 tons and in 1908-09 only to 109,000 tons. This year conditions are altogether abnormal, but taking into account the increased acreage and the excellent weather conditions some authorities consider that the export figure will be a record one. More than two-thirds of the exports in normal years go to the United Kingdom : the other principal purchasers are Belgium, France, Italy and Egypt.

As early as 1877 a complete report on Indian wheat was called for by the Secretary of State for India. Samples of all the Indian wheats grown were sent to England, where they were examined by Forbes Watson. Milling and baking tests were also applied to representative samples. The result of Forbes Watson's examination was most satisfactory and it was clear

that India was capable of growing wheats of the highest quality, it being found that a considerable number of the samples sent from India were far superior to any of the Indian wheats usually seen on the London market. This, however, was probably due to the fact that the samples were selected and were better grown wheats than the ordinary trade consignments. When subjected to milling tests they showed no particular superiority.

Be this as it may, had India at this time possessed a staff of economic botanists who could have followed up this opinion, they would have set themselves the task of selecting these superior strains and developing them. But there was no one who could undertake this obvious line of work and attention was directed to the eradication of rust, an affection to which Indian wheats are peculiarly liable. The line taken was the introduction of exotics—principally from Australia—so that rust-resistant varieties might be acclimatized. A good deal of interest was taken in the matter in Australia. Farrer recommended hybrids between a good rust-resistant variety and Indian varieties, but the results with these at Cawnpore and Nagpur were unsatisfactory. Some slight measure of success was achieved in the Punjab, but what was gained in rust-resistance was lost in milling and baking qualities and in yielding power.

Many attempts to introduce Australian, English and North American wheats were made in the provinces, but all ended in failure, the main reason apparently being that the new varieties matured too late and were therefore either withered up by the hot winds or killed off by rust. The results would probably have been better had rapidly maturing varieties been introduced from the Mediterranean or Southern Russia, where conditions are, to some extent, similar to those in India.

Greater success was achieved in the introduction of Indian varieties into new localites. Seed from the United Provinces was sent to the Southern Shan States of Burma and an agricultural industry, sufficient to meet the local demand, has been established there and in the Chin Hills. Buxar wheat was distributed widely in Bengal and Muzaffarnagar wheat in Bombay, Sind and Bengal. In the United Provinces depôts

were established for the distribution of Muzaffarnagar wheat, which proved much superior to the local variety, with a view to encourage an export trade.

If early workers did little to improve the variety at least they extended the area. This was something gained and except in years of deficient rainfall India is now practically self-supporting.

Such was the record of achievement, and such the position, when Mr. and Mrs. Howard arrived in India. Forbes Watson had indicated that India could produce wheats of first class appearance and that it already possessed wheats of better grade than it put on the market. On the economic side India produced enough wheat for home consumption and ranked third (after Russia and the United States) as an exporter of wheat. The problem was to improve the crop on lines which would suit both the local taste and the export market.

The first task, therefore, which the Howards set themselves, was to find out these better varieties and study their characteristics. They undertook a complete survey of Indian wheats and separated type specimens of almost every Indian variety. From the wheats of the Punjab 25 types were isolated. These, it was proved, yielded as pure types enormously increased outturns, though great variations in yield were found. None of the Punjab wheats however indicated any " strength " a point of great commercial importance as English millers want " strong " wheats to mix with the " weak " varieties grown in England and imported largely. A strong wheat is necessary to produce large well-shaped or well-piled loaves. Most of the wheats of the world are weak or starchy, poor in gluten and, when baked, give heavy loaves. To obviate this, strong flours have to be mixed with the weak varieties. If, therefore, India can produce " strong " wheats she will command a special market and preferential prices. She will also meet the taste of the local market, for Indians appreciate good flour. The introduction of this quality of " strength " into Indian wheats becomes, therefore, a problem of primary importance.

But, besides want of " strength," the Howards detected other defects in these pure types. They found that all Indian wheats

have weak straw—another serious disadvantage. In India the winter rains are often accompanied by high winds and in March hot dry winds prevail, with the result that the crop, if the straw is weak, is laid by rain and wind and much damaged. Weak straws, moreover, are very brittle and much loss of grain occurs when the crop is laid. It is essential, therefore, to strengthen the straw so as to obviate these dangers, and also that it may be able to carry the heavier heads which improved cultivation will produce.

Another important point is that the wheat should mature early. The Indian wheat season is a short one. There is the danger of rust about the time of flowering and the possibility of drying up by early spring hot winds. In particular, it is desirable to obtain varieties which rapidly pass through the stage between flowering and ripening so as to minimise the risk of rust. In their investigations the Howards found in all Indian wheats a great liability to rust and in some varieties a great tendency to shed the grain. Finally varieties differ in yield. This is also a varietal character: though good cultivation, of course, increases yields.

To eliminate these defects and obtain those qualities which are essential in a good wheat was the problem which the Howards set themselves. So far as "strength" of flour was concerned, rapid progress was made by selection from existing varieties and their propagation as pure types. For the other characteristics such as strength of straw, experiments on Mendelian lines have been conducted and are in progress. Briefly put, this process consists in introducing into a plant, by cross-breeding, any quality in which it is deficient. The complexity of the problem will be recognised when it is remembered how many characters it is necessary to combine in the one wheat. Systematic selection and comparison had to be carried out with patience and discrimination from the second to the sixth generation before the well known Pusa 12 could be fixed as a type.

From the results already achieved there is good reason to believe that Pusa wheats, obtained either by selection and pure culture or by hybridisation, are the future wheats of India. But if in any tract they should prove unsuitable (though this

is unlikely) the *technique* for improvement has been suggested by the Howards' work and local workers following similar lines can bring local varieties to the highest pitch of perfection of which they are capable.

The ultimate judge of the export market is the baker, who wants a strong wheat capable of making a well-piled loaf. To this ultimate test the Pusa wheats have been subjected by an expert—Mr. A. E. Humphries—and they have emerged triumphantly. As milling and baking wheats they have been placed above all the wheats of India and ranked, by some of the trade, with Manitoba Spring wheats—the wheats which are in greatest demand for bread-making in England and which command the highest prices.

There remains the question whether the special qualities of the new wheats which, we have seen, are welcomed by English millers, suit the local consumer, who is the person principally affected by any change in the quality of his staple nourishment. Any improvement in quality must satisfy both classes of consumers, the people of India on the one hand and English millers on the other. Fortunately the tastes coincide. Numerous enquiries and tests have been made and it is gratifying to find that the Indian consumer has expressed a preference for the varieties which are finding favour on the English market.

Finally arose the question whether these Pusa wheats would be equally successful in other provinces, and in a new environment. Extensive experiments have demonstrated that this is the case and that, too, under the most unlikely conditions. Samples from stations so far apart and distant from Pusa as Lyallpur, Mirpurkhas and Gurdaspur were pronounced to be even better than those raised at Pusa. Mr. Humphries has noted that the progeny appear to possess intact the great strength of the strong parents. Seed distribution is being energetically pushed in the United Provinces, the Punjab and especially in Bihar, where local planters are giving valuable assistance. Experiments are being continued in the Central Provinces and everything goes to shew that the problem of environment has been solved. High grain quality can now be obtained in all the great wheat-growing tracts of India,

including the Punjab and the black cotton soils of Peninsular India, with or without irrigation, and there is no longer any reason why the distribution of inferior seed should be continued since increased yields and better quality can be obtained almost everywhere.

The first set of improved Pusa wheats has now been widely distributed and seed farms are being opened in all the main wheat tracts. They will still be grown at Pusa as pure cultures so as to maintain the type and from this supply seed farms can be restocked when necessary.

But the task is not finished. Work still goes on to improve the best of the Pusa wheats in standing power, rust-resistance and general hardiness. For this purpose crosses between Indian wheats with good grain quality and various English and American varieties were made in England in 1910. Two series of these hybrids are now in the fourth generation and from these it is hoped that the strong straw, rust-resistance and general vigour and hardiness of the English parent will be introduced into Indian wheats.

It is impossible to estimate the value or importance of these results to the agricultural prosperity of India, but the work of Mr. Howard and his talented wife can always be referred to as a great achievement accomplished in a remarkably short space of time. So rapid has the progress been that arrangements have been made to ship to England this year trial consignments of Pusa wheat, in order that its value may be tested on a commercial scale. The education of the home market is not the least important stage in the work of improving Indian wheat and the fate of these trial shipments will be awaited with interest.

While the bulk of the work on wheat has been concentrated at Pusa, workers in the provinces have not been idle. Complete surveys of local wheats have been made and the best varieties selected. Cultivation and manurial experiments have been carried out. But the success of Pusa wheats, under all environments, has been so great that the tendency is to adopt these in the wheat-growing provinces, and provincial workers are loyally co-operating with the Howards in endeavouring to

establish Pusa wheats throughout India. The maintenance in the provinces of pure types of these wheats, the multiplication of seed farms and the development of an organisation for distribution of seed, combined with attention to details of cultivation, are matters in which deputy directors can assist and this, it is satisfactory to know, they are doing. So far as one can predict, the establishment throughout India of these Pusa wheats is the solution of the improvement of Indian wheat.

It has been calculated that a safe estimate of the gain to Indian wheat-growers, if the crop were replaced by varieties like Pusa 12, would be Rs. 15 per acre per year. The rate at which extension will take place will depend on the efficiency of provincial organisations for seed distribution. In view of the favour with which these wheats have been received and the cordial co-operation of provincial officers it is a modest estimate to assume that in the course of a very few years the area under Pusa wheats will reach at least five million acres. This means an increase in the near future in the value of the agricultural produce of India of 750 lakhs of rupees or five million pounds.

CHAPTER VII.

Rice.

As wheat is the food of Northern India so rice is the staple food of the eastern provinces and Burma. The statistical data of this crop are striking. The area exceeds 80 million acres. Thirty-five per cent. of the total cultivated area of India is under rice; in Assam nearly 80 per cent., in Burma 74 per cent. and in Bengal 70 per cent. The total value of the exports is about 18 millions sterling. About 9 per cent. of the total production is available for export, the remainder being consumed locally. India's share of the world production of rice is about 46 per cent. and she is the largest exporter of rice in the world, Burma alone contributing three-quarters of the total Indian exports. In addition Burma also exports rice to India and it has been estimated that Burma ships as much rice to India proper as the rest of the world sends to western markets.

It is probably due to the magnitude and complexity of the subject that little progress has so far been made with this crop. The varieties of paddy are legion and, from the fact that it has been grown on such a scale for so many years, the disentanglement of the admixture of varieties is practically hopeless. Although considerable progress has been made, the preparation of a botanical classification will be a work of many years and it is doubtful whether, when completed, this will be of much value otherwise than as a means of reference for the local worker. A classification on broader agricultural lines, with reference to the period of growth, yield, etc., would be of greater practical value and this should be prepared as a ground work for improvement.

The problem really varies from province to province, but everywhere, except in Burma, may be looked at merely from the point of the local food supply. In such cases the people themselves are probably the best judges of varieties. Where rice is the general food of the people they themselves become specialist judges and the best basis for a classification would

probably be the varieties which are most popular with them. This would considerably lessen the scope of the enquiry. The original collection, on this basis, would be large, for every district has its own local names, but a careful agricultural study of all varieties, grown side by side, would soon make it clear that large numbers of these are the same. Further study would soon demonstrate which were the best.

As rice is the food of such a vast population it seems desirable that the question of its nutritive value should receive attention. This is a question for the chemist. Some work on it has already been done by Mr. Hooper, but, in provinces where rice is the staple food of the people it is probable that this investigation should form the basis of selection. It is not indeed improbable that the most nutritive strains may also prove to be high yielders. In any case selections so made can be tested and experiments with the selected varieties can be conducted with a view to increase their outturn and yield. A certain amount of work on these lines has already been done by Warth in Burma and Meggitt in Bengal and as more than half the rice exported to Europe is used for human consumption this is a line of investigation which may considerably increase the value of the crop in the European market.

In Burma, where rice is not only the universal food of the people but a large export crop, this question of nutritive value is of considerable importance. And, as more than a-third of the exports of Burma rice goes to India, improvement on these lines would meet the taste of this considerable market and might even increase the demand. In point of fact Burma rice is at present very much inferior to many of the Indian varieties, but there seems no reason why it should not be improved up to the quality desired.

As an indication of the lines on which work on this crop is being conducted it will probably be sufficient to give an account of what is being done in Burma, where the crop is of greatest commercial importance.

The problem presented to the department in Burma by the rice trade is the general production of a white grain of even milling quality. This is a counsel of perfection and no parti-

cular stimulus is given by the offer of a preferential price. Burma dominates the rice market of the world and can set the standard. Competition amongst brokers leads to reckless buying without discrimination of quality and the cultivator has not the inducement of a higher price to make him trouble much about the improvement of his crop. As things stand an increased yield would probably be a greater advantage to the cultivator. But the present position is economically unsound, and the department is right in attending to quality as well as quantity.

The problems underlying the improvement of Burma rice refer particularly to the shape, colour, uniformity and consistency of the grain. A primary rough classification has therefore been made with reference to these qualities and single-ear cultures have been separated and arranged accordingly. Coloured grain is highly objectionable and any culture showing this defect is summarily rejected.

In addition to the essential qualities of the grain the agricultural characteristics must be considered, the most important being growth-periods and yields. The results of this work will give a standard collection of the paddies of the provinces with accurate details of each.

This, however, is a tedious process and will take time. Side by side with this work, therefore, inter-varietal selection has been taken in hand. Half a dozen varieties which already possess an established reputation among millers and cultivators —types suitable for the export market—have been selected. These have been grown and studied, plants which show marked superiority being selected and the seed separately collected. This will again be sown and the variation in growth-period, resistance to disease, standing power and uniformity of ripening observed. Finally the grain-weight and straw-weight of each will be studied. As a result of this a final selection of the best varieties will be made and the seed of these selected cultures will be propagated for distribution on a large scale as rapidly as possible. Each selection will be given a name and number and these, as well as its history, will finally be entered in a pedigree register. It is scarcely necessary to add that before

any variety is distributed it will be thoroughly tested on a field scale.

The work is being duplicated by McKerral at Hmawbi with unirrigated rice and by Thompstone at Mandalay with irrigated. If nutritive tests are also applied by the agricultural chemist, a rapid improvement in Burma rice may confidently be expected.

With regard to red grain—which is a trade disadvantage—preliminary experiments indicate that redness and whiteness are Mendelian characters and the solution of the problem is being worked out on Mendelian lines. A complication, however, is natural crossing—a problem which has also been investigated by Hector at Dacca.

Spacing and manurial experiments are also being conducted in all provinces. With regard to spacing it is probably unsafe to lay down any definite rules for any but the locality where the experiment is conducted and among Burman cultivators the rule is that the better the soil the greater is the tillering and hence the greater the planting distance required.

As regards manures, on which a good deal of work has been done, the general experience appears to be in favour of green manuring for transplanted paddy. Bonemeal is, however, in many provinces reported to give good results and it would be a great advantage if the local crushing of bones were extended. The present large export is an enormous agricultural loss to the country. General experience is against chemical nitrogenous manures except cyanamide and possibly sulphate of ammonia, but the cost of these is a serious handicap to their general adoption. A limitation on the use of artificial manures is also imposed by the fact that as the plant is aquatic and the fields always covered with water, soluble manures are apt to be washed away.

On the agricultural side the effects of hot weather cultivation and of ploughing in the stubble immediately after harvest have been tried. Experiments on seed rate and the number of seedlings have led to a saving to cultivators in Madras which is estimated at 10 lakhs annually. The seed bed is sown thin instead of thick, as was formerly the case, and plants are

planted out singly or by twos and threes and not in large bunches, which was the local custom. Similar experiments are being carried out in other provinces.

A remarkable achievement in connection with rice—although it involves no new discovery—has been the success which has attended Mr. Clouston's efforts to introduce transplantation of paddy into the Chhattisgarh division of the Central Provinces Here, till seven years ago, the primitive custom of broadcast sowing was universally practised. About 100 lb of seed per acre were broadcasted and the young seedlings were subsequently thinned out by ploughing with the result that most of them were killed. After a series of experiments on the Raipur farm which demonstrated a profit of about Rs. 15 per acre if transplanting were adopted instead of broadcasting, steps were taken to bring this improvement before the notice of cultivators. The new method has been demonstrated in thousands of villages during the past five years by a staff of trained men of the ploughman type working under agricultural assistants. The work has been accelerated by the co-operation of the district authorities, and is now so firmly established that it has been handed over to the revenue staff, who work side by side with the agricultural assistants. The result has been that the area of transplanted rice has risen to over 30,000 acres, which means a profit to the cultivators of $4\frac{1}{2}$ lakhs of rupees per annum.

There was no new discovery involved in this, and it may be said that few workers have such an opportunity presented to them as the backward condition of Chhattisgarh offered. But this does not detract from the value of the work and every credit is due to Mr. Clouston for the patience and tact with which he has managed to improve so materially the agricultural practice of a conservative and lazy tract.

The insect pests and fungus diseases of paddy present a vast field of work, with which it will probably be impossible to grapple until the entomological and mycological staffs are enormously increased. The fungus diseases of paddy, which, fortunately, are not yet very numerous in India, have been investigated by Dr. Butler and concerted action is being taken against *ufra* in Bengal, a disease supposed to be caused by an

eel-worm. Many of the insect pests of paddy have also been discovered. But the difficulties are the enormous tracts affected and the difficulty of control. Burning the paddy-straw on the field is probably the most effective cure for such diseases as are not carried in the seed or in the ground, but the claims of the cattle have to be considered as the wholesale burning of straw seriously affects their food supply.

If, however, small local outbreaks are promptly reported, they can probably be dealt with before they spread and become universal.

Harrison's important work on the Gases of Swamp Rice-lands will be referred to later.

CHAPTER VIII.

Sugarcane.

In comparison with the crops we have already discussed sugarcane, though of much importance, occupies a humble place in the agricultural economy of India. Foreign competition, principally in the form of Java sugar, has hit it hard and imports have increased in 25 years from 70,000 tons to over 800,000 tons This has tended to a considerable diminution of the area under the crop in certain provinces, notably in Bengal, Bombay and the Central Provinces. But, as a set-off, there have been large increases in Madras, the United Provinces and Assam and the average outturn per acre has also increased.

The total area under sugarcane in 1913-14 was 2,519,800 acres, of which the United Provinces contributed 1,379,900 acres and the Punjab 411,200 acres. It will be noted that Northern India has a predominating interest in this crop. On the other hand while the area in Southern India is small we find there much thicker and finer canes than in Northern India.

The total yield of the crop of 1913-14 was estimated at about 2,600,000 tons of sugar and *gur* and 460,000 tons of palm sugar, of which only 16,000 tons were exported—mostly to the United Kingdom. On the other hand, over 800,000 tons of a value of nearly 10 millions sterling were imported. Although, therefore, India is the greatest producer of cane sugar in the world she cannot meet her own needs.

The early history of the treatment of this crop in India can be dealt with very briefly. In Bengal successful experiments were conducted at Burdwan in manuring, planting in parallel trenches and "ratooning." In the United Provinces and Burma iron crushing-mills were substituted for wooden ones. In Bombay manurial and varietal experiments were carried out. To the earlier days belongs also the introduction of the Hadi process of sugar manufacture as a village industry, which, after promising well, was unfortunately found to be unsuitable for general adoption.

We have already mentioned the difference between Northern and Peninsular India as regards the quality of the cane, and this is of importance. In Peninsular India, which falls within the tropics, thick canes predominate and yields are large. Great care is often taken in cultivation and comparatively heavy doses of nitrogenous manures are given in the form of oil-cake with excellent results. But, though the quality is so good, the crop is relatively unimportant. The area under it is small and is limited by the amount of water available and the quantity of paddy grown. It is in fact a luxury crop and as such is grown on a very small scale on any one holding.

The great North Indian sugarcane tract, on the other hand, is not in the tropics and the climate is, in fact, better suited for wheat than sugarcane. Except in some of the submontane tracts of the United Provinces and the Punjab, where thick canes and heavy yielders succeed, the canes are thin and, as a rule, short. They display no tropical luxuriance but they are hardy against drought and water-logging and are consequently often grown on unsuitable land.

Dr. Barber has said that the limiting factor in cane-growing in South India is water and in North India warmth. The latter is generally insufficient for the ripening of tropical canes and they cannot hold their own with the small local varieties which for centuries have been adapting themselves to local conditions. The growing period also in South India and Burma, if canal, well or river water is available, is 12 to 14 months; the growth period in North India is much less.

There is, however, little indication of a desire to expand the industry in Southern India and it is to the large sugarcane tracts of Northern India that attention must be devoted if India is to become self-supporting.

The systematic study of sugarcane may be said to date from 1901-02, when, in consequence of the destruction of the crop in Madras by "red rot," Dr. Barber started the well-known Samalkota farm, where efforts were made to discover "red rot" resistant varieties. "Red Mauritius" was found to be the hardiest. Arrangements were made for its distribution and by 1912 the area in the affected tract had risen from 4,000

to 9,000 acres, while the cane was also distributed in new tracts.

Before coming to Madras Dr. Barber had worked on sugarcane in the West Indies, and in Madras he kept sugarcane in the fore-front of his work. A specialist thoroughly conversant with his subject and with a large amount of preliminary material was, therefore, available.

The Board of Agriculture at its meeting in 1911 recommended that the question of sugarcane improvement should be seriously taken in hand. Public opinion was awakening to the threatened danger to the industry by the annually increasing imports of sugar from Java. Cheap refined sugar was not only being largely consumed as sugar, but was being mixed with Indian sugar in the manufacture of *gur*. It is as *gur*—an inferior soft brown sugar—that a very large proportion of the sugar of India is consumed. The sugar problem has, therefore, to be considered both from the point of view of refined sugar and of *gur*. The former is most affected by the imports of foreign sugar but, so far as the improvement of the varieties of cane is concerned, the problem is the same whether *gur* or white sugar is ultimately manufactured. And in view of the different purposes to which sugarcane is put both aspects of the question must be attended to, the improvement and the fostering of the indigenous methods of *gur* making as well as the production of cheap white sugar.

The present state of things in India is due to three causes: first, wrong and wasteful methods of manufacture; secondly, poor varieties of cane; and, thirdly, bad cultivation. There are thus two problems to be faced. On the one hand there is the mechanical or engineering problem, which is to discover the best methods of extracting and concentrating the juice to yield *gur* or white sugar on a scale within the means of small cultivators or groups of cultivators or of the Indian capitalists now engaged in the industry. Next, and of far greater importance, there is the agricultural problem, which, as in the case of all other crops, can only be solved by the survey and testing of local varieties, the improvement of varieties by cross-breeding, the distribution of the best varieties, manurial and cultural

tests and the development of an organization for the demonstration of improvements and for extension of cultivation.

As a result of the recommendations of the Board of Agriculture a skilled sugar engineer (Mr. W. Hulme) has been employed in the United Provinces. Considerable success has already been achieved in the rearrangement of factories which were formerly working on wrong lines and experiments are being carried out to devise a machine which can be worked cheaply and which will be suitable for sugar making on a small scale by small cultivators or groups of cultivators. Mr. Hulme has also given a great deal of attention to the introduction of a better and cheaper crushing plant and a more economical boiling process for the manufacture of *gur*. On the agricultural side the central control in sugarcane work is vested in Dr. Barber, who has been appointed sugar expert.

The main lines on which he is working have been suggested by the experience of the sugarcane growers of Java. Between 1882 and 1892 the sugarcane crop of Java was devastated by disease and although scientific investigations were carried out no remedy was found. It was then decided to import canes from other countries. A number of these imported varieties proved to be less subject to the disease than the local canes and thus the industry struggled on, but none of the imported canes were altogether satisfactory. The important discovery, however, that canes produce seed opened up a new possibility, and by the use of a resistant parent for cross-breeding the industry has been completely re-established in Java.

A similar calamity visited India. The Samalkota station was started but work was confined to the introduction of canes from other countries in the hope that by this haphazard method some might be found to replace the dying canes of Madras. The results, Dr. Barber notes, were unexpectedly and perhaps undeservedly successful and Madras may now claim to have as fine a set of canes as any part of India. But the method is tedious and costly and many disappointments are met with. Of the canes imported it is found that none are really immune and there is always the risk that they will ultimately succumb when faced with the adverse conditions of local agriculture. Further,

hardly any of these varieties are suitable for introduction into the large areas under cane in Northern India. In these tracts we find that the better class canes, which are heavily diseased, have given place to inferior but hardier varieties and in Dr. Barber's opinion the varieties in the great sugarcane areas of the north of India are among the poorest in the world. In the east of the United Provinces, North Bihar, certain parts of Assam, Burma and the Central Provinces there are a number of canes which have been introduced in recent years—Barbados, Java and Mauritius seedlings and Samalkota canes—which may succeed, and the introduction of hybrids may not be necessary. But the fact remains that the local canes grown by the cultivators and on which many factories wholly or partly depend are poor yielders.

The problem, therefore, with which we are faced is the introduction into the main sugarcane tract of Northern India of richer canes giving higher yields, with greater resistance to disease and yet adaptable to the methods of cultivation employed by the cultivator. Improvement in cultivation is only likely to come if the variety of cane provided is worth intensive cultivation.

There are several ways in which the improvement of Indian canes may be attempted. An effort may be made to select better strains from the existing varieties at present grown. Again, canes of better quality may be introduced from countries where scientific work has been carried on for years. Lastly the production of seedling canes, which has worked such a revolution in Java, may be tried in India also. The first two methods may succeed and, indeed, have succeeded in Southern India. But, as a general principle, it has been found that these imported canes, all of which come from the tropics, are not suited to the sugar tract of Northern India or the prevailing methods of agriculture. The tropical thick canes, which require good cultivation and heavy manuring, are often out of the cultivator's reach for lack of the means to cultivate them properly. What is wanted is a more hardly type of cane capable of holding its own with the canes grown under field conditions in Northern India. Such types are not usually available among the canes

grown in tropical countries, and it is to the production of these that Dr. Barber has devoted himself. Coimbatore has been selected for the work as it has been noted that canes there flower every year and produce pollen.

The work of the sugar expert is in the main directed to the production for Northern India of superior hybrid seedlings between the local northern canes and the best southern canes. These hybrids will, it is hoped, eventually displace the inferior local varieties. The aim is to obtain such hybrids as will grow under raiyats' conditions and given a greater yield under the same treatment as is at present devoted to the crop. With such canes it is hoped that the cultivator will be induced to improve his cultivation. At present the margin of profit on jaggery manufacture is very small and it is improbable that there will be any permanent extension or improvement until the raiyat is provided with better hardy hybrids. The thicker canes are useless because they will not grow under the treatment they receive.

The first duty of the research station therefore is to produce hardy hybrids to supplant the present inferior local canes. But there is also another aspect of the work. It has been found that canes under cultivation have only a certain length of useful life, after which they have to be discarded. A batch of good new canes will only last a certain time, after which they will die out on account of deterioration and disease. Improved canes, introduced through the Samalkota farm, have disappeared in eight years. A similar fate will overtake the thick imported canes in other provinces and new hybrids. Cane-breeding must therefore never slacken if the wastage is to be made good, and to effect this the number of stations and workers must be increased.

Such is the work on which Dr. Barber is engaged on his own research station at Coimbatore. The seedlings and superior canes, when sufficient have been obtained, will be distributed to provinces. Dr. Barber also advises provincial officers in the survey and selection of the best indigenous varieties and on the method of propagating hybrid seedlings and since his appointment great advance has been made in the provinces. In the United Provinces farms have been opened at Nawabganj, near

Bareilly, for the collection and growth of the canes of the tract and their comparison with imported varieties, and at Shahjahanpur, for chemical work, under Mr. Clarke. A sugar station is to be opened in Bihar, while much good work has been done by Messrs. Taylor and Woodhouse at Sabour. A large area has been taken up in the Kamrup district in Assam, where the thick canes already successfully grown at Jorhat will be developed on a commercial scale. Large areas in this province, apparently suitable for cane growing on a commercial scale, have been located and surveyed. In the Punjab much excellent work has been done on sugarcane by Messrs. Barnes and Southern and the survey here and in the Central Provinces is being rapidly pushed on. In the latter provinces an option over a large area for a factory has been given to Mr. McGlashan of Cawnpore, and a nursery of canes has been laid down at Sindewahi to start it. In Burma a Rangoon firm proposes to experiment in the Mon canal area with the assistance of a Java expert, Government contributing half the cost.

It will thus be seen that serious efforts are being made to encourage the industry and the prospects of success are good.

It only remains to refer to Mr. Annett's work on date-palm sugar and Mr. Robertson-Brown's experiments with sugar-beet at Peshawar. It is perhaps too early to record any results as the work is only in the experimental stage and success will depend on a clear demonstration of financial possibilities. The problems of the former are improvements in extraction and manufacture and in co-operative organisation.

CHAPTER IX.

Jute and other Fibres.

Jute.—Of the fibres of India jute is, commercially, by far the most important. India is the only country which produces it on any scale and, within India, its cultivation is limited practically to Bengal and Assam. Experiments, however, are being tried with it in various parts of the world and there is thus the chance that Bengal may lose its monopoly of this crop. There is another danger. The greatest recommendation of jute has always been its cheapness. This advantage is disappearing and the high prices which have ruled in recent years are beginning to cause some uneasiness lest, like indigo, it may be supplanted by a synthetic or natural substitute. The area under this crop varies, but averages, in recent years, about three million acres.

Another feature of the crop is that part of it is exported as raw jute, compressed in bales for manufacture in Europe (principally at Dundee), while the remainder, apart from the amount consumed locally, is manufactured in India and exported as gunnies and cloth. On an average, about half the crop would appear to be exported as raw jute, and the remaining half as manufactured goods. The last recorded figures give exports of raw jute at 4,303,000 bales of a value of 30,83 lakhs of rupees or £20,553,334. The United Kingdom is our best customer, but Germany, the United States and France are also heavy purchasers.

The local manufacture of jute has expanded enormously in the last ten years and the number of jute mills in Calcutta has increased from 38 to 66.

Although the export of raw jute from India in any quantity probably only commenced about 90 years ago (the figures given for the year 1828 are just over 300 cwts.), its cultivation on a considerable scale has been carried on from a remote period. Buchanan Hamilton estimates that there were, in

1802, about 20,000 acres under jute in Rangpur. The whole of the jute produced was manufactured in India; and there was a considerable export of jute gunnies and packing cloth. At that time, however, gunnies were made from other fibres, and those exported from the Ganjam and Vizagapatam coasts were in all probability made from *Hibiscus Cannabinus*. Once the export of raw jute had been firmly established (about the year 1828) the trade increased rapidly and the Crimean war gave it a strong impetus.

So far back as 1872 jute was cultivated in 47 out of the 58 districts of the old Bengal Presidency and at that time the area under the crop was less than one-third the present acreage. It would appear, therefore, that the cultivation of jute in the past was spread over almost as wide an area as it is at present and that the large expansion in production is due rather to an increase in the percentage of jute cultivation in the old districts than to its introduction into new tracts. Even in 1872, when less than a million acres were under jute, it was feared that the large increase of jute cultivation would in some districts interfere with the cultivation of food grains as it was fairly certain that at least two-thirds of the area then under jute was formerly devoted to food grains.

The demand for an investigation into the possibility of improving the yield—and incidentally, if possible, the quality—so that jute might not further encroach on the area devoted to food crops thus arose quite naturally. A commission was appointed in 1872 to investigate " the cultivation of, and trade in, jute in Bengal " and a voluminous report was issued two years later by Hem Chandra Kerr. This may be taken as the starting point of experimental work in connection with jute.

It is interesting to note that, even then, some people thought that the jute fibre was deteriorating. Hem Chandra Kerr's report admits that a larger proportion of inferior fibre may have been coming into the market, but attributes this not to any intrinsic deterioration in the plant but to defective cultivation and preparation and also, to some extent, to fraudulent watering. These matters were again represented seventeen years later—in 1901—when the Calcutta Baled Jute Association

asked Government that the Agricultural Department should examine whether the cultivation and yield of jute could be improved. This was acceded to and a sub-committee of the Board of Scientific Advice was appointed. During the years 1902-03 the practice of fraudulent watering appears to have increased considerably and the outcry regarding deterioration was renewed, accompanied by an insistent demand from the trade for penal legislation.

Mr. Finlow was appointed Government fibre expert in 1904, and, since that date, work on jute and other fibres has been concentrated in his hands. The first investigation was to determine the normal moisture content of the fibre and, later, to examine a considerable number of watered samples in order to gain some idea of the extent to which adulteration was practised. It was next necessary to examine what the maximum moisture content should be in case legislation required a standard. These investigations showed that although the watering of jute to a considerable extent was very common, any legal standard would have to be fixed in the neighbourhood of 25 per cent. moisture, which is at least 10 per cent. higher than the normal moisture content of good jute fibre. Penal legislation would therefore have legalized the fraudulent addition of 10 per cent. of water.

Government finally decided that the real cause of the evil was an insufficient supply of jute, the obvious remedy for which was to increase the quality and yield by improved cultivation and seed selection and also to extend the area devoted to the crop and similar fibres. These considerations have determined the lines on which all subsequent work has been carried out.

In 1905 Mr. Finlow made an extensive tour through India to investigate the possibility of extending the cultivation of jute or similar fibres in tracts outside those in which it is at present grown. Extensive trials carried out in tracts representative of a large portion of India, shewed the successful cultivation of jute to be quite possible over a wide area outside the jute-growing districts and that in Burma, Asssam and North Bihar the area is capable of a large extension. But the dearness and scarcity of labour are obstacles. In other tracts—the irrigation colonies in the Punjab for instance—the crucial diffi-

culty which would prevent jute cultivation on any large scale would be the want of retting facilities. It is, however, probable that other means of extracting the fibre may be brought into use in the near future.

In 1906 Mr. Finlow, in collaboration with Mr. I. H. Burkill, commenced an elaborate survey of the races of jute in Bengal, both by an examination of crops in the field and by the study of plots grown from seed obtained from all parts of the jute-producing tracts. It was found that very wide and important differences existed between *C. Capsularis* and *C. Olitorius*. Some races have a considerably taller stature and therefore—other things being equal—a correspondingly greater yielding power than others. A suitable basis for pure line selection as regards yielding power was thus found and work on these lines has been continued. At the same time, in order to secure a better fibre, a careful chemical and microscopic examination of the fibres of different races was adopted as a second basis for pure line culture. So far no single plant has been found which combines in the highest degree the two most desirable qualities, *viz.*, high yielding power and strength and durability. Some, however, approximate to this criterion and it is hoped ultimately to obtain what is required by hybridisation. In the meantime the seed of pure lines have been isolated. Some of these pure lines have been multiplied and seed is now available for distribution. A campaign of considerable magnitude has been organised for the final testing of these pure lines against local races. It is quite certain that they are amongst the heaviest—if not actually the heaviest—yielders in the province and the tests will soon shew whether they are absolutely the best or not. In any case it seems clear that in the near future the best will have been obtained and, in the meantime, it is quite safe to multiply the pure lines on a very large scale in the certainty that this seed can advantageously replace the very large amount of poor bazaar seed which is at present bought for sowing over large areas.

The distribution of improved seed, it should be added, is rendered the easier because its flower is normally self-fertilised. This has been proved by hybridisation experiments carried out by Mr. Finlow in collaboration with I. H. Burkill.

Manures and cultivation.—While the selection and breeding of improved varieties has taken up a large amount of time, improvements in cultivation have not been neglected. The early experiments at Burdwan shewed that, on a normal soil, the cheapest and most effective manure is cowdung and all subsequent work has supported this conclusion; but it has also been shewn that oil-cake can profitably be applied.

It is obviously advisable, therefore, to utilize the supply of cowdung to the best advantage. But to secure such a desirable end involves making available as a manure a large proportion of the nitrogen which is so largely wasted in Bengal, as well as in other parts of India, by the use of cowdung for burning and other purposes. The loss is, of course, greatly aggravated in Bengal by the heavy rainfall. Jute is a rapidly growing crop, producing, as it commonly does in Bengal, twenty tons per acre of green matter in a growing period of less than four months and the best results with jute are obtained where intensive methods of cultivation and manuring are followed. On this account it is for jute, at least as important, if not more so, than for any other crop that the wastage of cowdung should be curtailed so far as possible. This vital matter was taken up a few years ago by Mr. Finlow. He persuaded cultivators to keep their manure in pits protected by rough sheds; the idea has developed and the conservation of cowdung is now taught by the department. Last year nearly 500 pits were dug and the practice will undoubtedly spread as, apart from the avoidance of loss due to physical agency, the superiority of pitted manure is well known.

Besides cowdung, artificial manures and oil-cake there must be reckoned green manures. It has still to be established that it would pay the cultivator of Eastern Bengal to lose a grain or jute crop in the rains in order to grow green manure, but the possibility of raising a quick growing catch crop such as cow-pea on high lands between the *kharif* and the *rabi* has now been established and will soon be capable of demonstration. The crop may either be fed off or ploughed in.

From what has been said it will be seen that, both as regards the production of pure strains of the best seed and improve-

ments in the methods of cultivation, results of great value have now been obtained and are ready for demonstration to the cultivator. It rests with the Agricultural Department of Bengal to organise the dissemination of these improvements through demonstration and seed farms and co-operative societies. The question is one of organisation. With this the responsibilities of the Agricultural Department end, the vagaries of the market being the concern of the trade.

Flax.—The attention of agriculturists in India has, from time to time, been drawn to the possibilities of flax cultivation. The decay of the indigo industry in Bihar induced the Bihar Planters' Association to take up systematic experiments and a Belgian flax expert—Mr. Vandekerkhove—was engaged by the association for five years (1908-1913). Complete experiments, both on the growing of the crop and its preparation for the market, were carried out on a business basis.

It was definitely proved that flax can be successfully grown and prepared at a profit of from Rs. 60 to Rs. 63 per acre. But there is no general inclination to take up its cultivation and manufacture as prices are uncertain and as planters are unwilling to sink capital in a new industry. But it has been proved that the crop can be grown in Bihar at a fair profit, and a possible investment for capital has thus been indicated.

Other Fibres.—Overshadowed by jute, none of the other fibre-producing crops of India are deemed of sufficient importance to be classified in the agricultural statistics of India. But there are about 800,000 acres under such crops, mostly in Madras and Bombay. The principal are *Sunn* hemp and *Hibiscus Cannabinus* (Bombay hemp or Bimlipatam jute). Originally grown for home consumption they are now being manufactured and exported, the latter as "Bimlipatam" jute. The examination of these and other fibres as possible substitutes for jute is one of the lines of enquiry on which Mr. Finlow is engaged.

Hibiscus Cannabinus requires a moderate rainfall. It is established in Madras and Bombay and is used for domestic purposes. *Sunn* hemp, which is a popular green manure and also a fodder crop, is grown for its fibre in the Central and

United Provinces and there is a regular trade in it. In the Central Provinces the seed is used as a cattle food. In many provinces these fibres are grown as mixed crops. These, with cocoanuts, are the principal fibre crops within the reach of cultivators.

It seems doubtful whether plantain fibre can profitably be manufactured in India, while agave and rhea require capital. A considerable increase of agave cultivation might be possible in Assam and in tracts which have similar physical and climatic conditions, but rhea requires very special conditions of climate and soil and its cultivation does not appear to be very promising.

Besides Mr. Finlow's preliminary work on fibres, the Howards have done a considerable amount of selection work on *Sunn* hemp and *Hibiscus Cannabinus*. The extension of the latter may bring it into competition with jute, while *Sunn* hemp might also prove a substitute if necessary.

Cocoanuts.—Cocoanuts have been called the " Consols of the East," but India has not, as yet, invested as much as she might in them. There is no waste about a cocoanut. The husk yields fibre; the kernel *copra* from which oil is expressed and the residue is compressed into cake. The industry is one which might be taken up more extensively on the west coast of Madras and in the maritime tracts of Lower Burma. On account, however, of the length of time one has to wait for a return, capitalist efforts must be looked to for any great expansion of the industry. But in these tracts of India the question is certainly worthy of investigation.

Beyond some entomological and mycological enquiries (resulting in much practical advantage to the industry) the Agricultural Department has not, so far, been able to devote much attention to this crop. As the exports—principally from Madras—are already valued at 284½ lakhs of rupees, it is clear that the industry has great financial possibilities. Systematic investigations will, it is hoped, be seriously taken up in Madras and Burma when a staff is available.

CHAPTER X.

Indigo.

The rapid decline in this valuable crop is one of the tragedies of Indian agriculture. Twenty years ago the area was well over a million and a-quarter acres; it is now only 131,700 acres and steadily decreases. The reason for this is the discovery and manufacture of synthetic indigo in Germany, and the difficulty which the natural indigo has had in competing with this substitute at the price at which the latter can be put on the market. The effects of this discovery were at once felt, and, since 1897, the indigo industry of Bihar has steadily gone from bad to worse. Heroic efforts have been made by the Bihar Planters' Association, with the assistance of Government, to rehabilitate the drooping industry. Although the area under indigo in Madras now exceeds that in Bihar, the crop has not the commercial importance that it has in Bihar, and in many places a large amount of the crop would appear to be ploughed in as green manure. As a commercial product the industry belongs to Bihar.

When synthetic indigo came to the front in 1897 the plant grown in Bihar was the variety known as *Indigofera Sumatrana*. This plant was a low yielder of colouring matter and it soon became apparent if any fight was to be made against the synthetic substitute that something better would have to be found. In 1898 Mr. H. A. Baily, a Bihar planter, visited Java and, as a result of his visit, introduced into Bihar what is known as Java indigo. The cultivation caught on and by 1910 the area under Java indigo exceeded that under the old *Sumatrana*. The plant gave a very large increase of colour and it was thought, not unreasonably, that this crop would save the industry.

Suddenly, in the monsoon of 1907, an insect pest called *Psylla* attacked the plant. In addition, the plant regularly wilted away as the result, it was supposed, of some unknown disease. The outturn was much reduced. The disease

steadily became worse. Java indigo could not be induced to form seed as the disease killed the plant before the seed set. The industry was on the verge of extinction. Work at the Planters' Research Station at Sirsiah, which had been opened for the scientific investigation of the crop, was brought to a standstill as selection work, which formed the main item of the programme of investigation, became impracticable when seed could not be produced. Chemical investigations were useless, it being a question of saving the life of the plant. The Bihar Planters' Association, in view of the great decline in the industry, could not face any further expenditure and it was decided that the investigations should be taken up by Mr. and Mrs. Howard at Pusa.

This is not a scientific treatise and I do not propose to discuss the numerous chemical controversies which have raged around indigo and indigo manufacture. Whatever importance they may assume when the growth of the crop is re-established, they are of little moment when it is a question of the life or death of the plant. On the question of manufacture the view taken by the Bihar Planters' Association is, in the circumstances, the practical one that the most efficient methods of manufacture now in vogue in Bihar, extract certainly not less than 70 per cent. of the total colouring principle. The present state of the industry does not justify further search for improved methods, which promise, at best, a further 15 per cent. of outturn in return for a heavy capital expenditure. If the indigo plant can be induced to grow healthily, and if the area and yield can be increased, the industry run on its present lines will be sufficiently remunerative and it may be possible to compete with synthetic.

Until the transfer of the work to Pusa attention had mainly been concentrated on the chemistry of the manufacturing process and very little work, beyond manurial experiments, had been done on the agricultural or physiological side. The inability of the plant to produce seed had also been considered by the Pusa staff. Mr. Lefroy did not consider this to be in any way connected with the *Psylla* or any other insect and Dr. Butler could not attribute it to any definite fungus. Mr. Hutchinson also found no indication of bacterial disease.

Such was the position when the Howards took the subject over. Mr. Howard had already expressed the opinion that the diseased condition was due to bad cultivation and water-logging of the soil and subsequent work has been devoted to proving this theory.

Three urgent problems presented themselves. In the first place it was necessary to discover some method of growing Java seed if the industry was to be saved. It was found that in wet years a crop of really good seed was impossible after cutting the indigo for leaf. Leaf-growing and seed-growing had therefore to be dealt with separately. For seed, Java indigo should be sown about the middle of August on highlying, well-drained and fertile land. The seed should be sown in lines about two feet apart so as to promote branching and ensure abundant pollination and thorough cultivation and cleaning of the seed beds is necessary. Proper aëration of the soil is, moreover, essential. A full supply of air to the roots is necessary for the production of a good crop of indigo seed. If grown in this way it is claimed that indigo escapes the so-called disease and large crops of good well-grown seed can be obtained. The disease, which ends in the wilting of the plants, is really due to long continued wetness of the soil, which destroys the young feeding roots. The theory has been verified in practice and good crops have by this method of cultivation been obtained at Pusa and on the Dholi estate.

The second problem was the improvement of the crop by selection. Parnell had found that in indigo pollination by means of bees was the rule and this view has been confirmed by the Howards. There is thus extensive natural crossing in the crop and any plant selected on account of the high *indican* content of the leaf is not likely to breed true but to give rise to all kinds of offspring as regards *indican* content. It has also been proved that the crop, as ordinarily grown, consists of several distinct types of plant, some of which grow much more rapidly and robustly and carry far more leaves than the bulk of the crop.

Ordinary single-plant selection methods are inapplicable to Java indigo. Hand-pollination throughout all stages of the

pure-line selection and breeding experiments would be necessary. The task of improving a character so difficult to estimate and so elusive as *indican* content would not be worth the great labour and expense involved.

The Howards propose therefore to take those individual plants in the mixed crop which grow rapidly and strongly and which by their habit of growth and amount of leaf-surface are likely to give the highest yield of leaf. These will be grown separately, apart from other indigo, so as to avoid cross fertilisation by bees. It is hoped, in a short time, to isolate by these means a superior type of plant with a larger yield of leaf and probably also a large outturn of finished indigo.

From this superior type further selection will be made for wilt-resistance. Experiments on these lines will be conducted both with Java and Sumatra as the latter will still continue to be grown as a catch crop after rice.

The third problem is the improvement of cultivation. The Howards recommend harrowing after the removal of the cover crop, pruning instead of cutting back, the removal of the crop after the second cut. As a cover crop they recommend Pusa wheat No. 4, an early maturing variety with little foliage and stout straw. Drainage of the land on the Pusa system, described later, is also recommended.

Although work has only been carried on for a couple of seasons the question of seed production seems to have been solved. The so-called disease has been shown to be no disease at all but merely the result of bad cultivation and water-logging, which not only kills off the plant but also, even if the plant survives, affects its *indican* content.

Indican is the colouring matter contained in the leaves. The plant itself has first to manufacture this raw material before it can be commercially prepared by steeping and vatting. On the natural process of the manufacture of *indican* in the leaf the Howards have arrived at some interesting conclusions.

Like all leguminous plants indigo has a high percentage of nitrogen in its seeds. After sowing, early development is most marked in the root system, which soon develops nodules. These contain bacteria which assimilate the free nitrogen of the air

and so feed the plant and also help it to make the *indican* in its leaves. Thus, in a sense, the first stage in the production of *indican* is the nodule of the indigo root and the source of this *indican* is the nitrogen of the air. Again, substances are passed down from the leaves into the nodules to feed the bacteria. The activity of the nodules depends on two main factors—a full continuous supply of air from the atmosphere and a supply of food from the leaves for the nodule bacteria. If, then, the soil becomes compact or water-logged the aëration of the roots ceases and the plant withers off and decays because the nodule bacteria cannot feed it. It literally becomes suffocated. All its functional operations cease. If, again, the plant is cut back too much, the leaf supply of food to the nodule bacteria ceases. It is for these reasons that the soil must be kept thoroughly aërated by constant cultivation and that the plants should not be cut down completely at the first cut. Some leaves should be left to carry on the transpiration current and to feed the nodule bacteria.

The work is only in its early stages. But the preliminary results obtained seem to indicate the possibility of again establishing the crop on a firm basis. Whether it can regain its old glory is a matter of cost of production and quality. When the industry has been re-established the services of the chemist and manufacturer will probably be again required. And the outlook is full of promise.

CHAPTER XI.

Tobacco: Oilseeds: Planters' Crops.

Tobacco.—Smoking is an almost universal habit in India and being a habit is hardly regarded as a vice. Cheap imported cigarettes can be bought in every village bazaar; in places they are supplanting the *hookah*. The imports of cigarettes in 1913-14 amounted to a value of nearly 58½ lakhs of rupees or £388,300, but it is satisfactory to find that these imports have, in recent years, been decreasing, due no doubt to the establishment of Indian factories for the manufacture of cigarettes from local tobaccos.

The opening of these factories has not only given a fillip to tobacco cultivation, but has also led to a study of the intricate questions of curing and manufacture, in which expert trade workers can give much assistance. On the other hand, there is the disadvantage of a monopoly which allows factories to fix a price and, when improved varieties are taken up on a large scale (as is being done by Bihar planters), higher prices will have to be offered if cultivation is to be encouraged.

The early attempts with this crop did not amount to much. A considerable sum of money was wasted in Burma in the early 'eighties in attempts to improve the methods of curing. More successful, though purely by accident, was the indiscriminate distribution of Havana seed, which has produced a superior variety in Lower Burma and in Arakan. Early experiments in the United Provinces demonstrated the unsuitability of the crop and no further money has been thrown away on it. In Bombay attempts to introduce exotics had the accidental result of producing a superior hybrid which ousted the local variety. In Madras early efforts were very spasmodic, and achieved nothing. It was only when manufacturers like Spencer & Co. and Mr. Barry came into the field that work on practical lines was seriously taken up.

The problems in connection with tobacco are two—improvement in the quality, curing and manufacture of the indigenous

varieties, and the introduction of finer exotic varieties or hybrids. But we must be careful not to lose in the process of improvement those distinctive characteristics which make the Burmese or Indian cheroot what it is.

The ordinary Burman and Indian cigar has an increasing popularity—about $1\frac{3}{4}$ million pounds are exported—and exports increase. It is a cheap and a good cigar, but it is capable of improvement, principally by a better outer leaf or wrapper of finer tobacco.

We should therefore aim at increasing the outturn of genuine Indian cigars, improved, as they can be, without loss of their individuality, by the selection of leaf, and at decreasing the imports of foreign cigarettes by producing tobacco suitable for this purpose. The present coarse varieties seem to meet the local taste and that of our main export markets, which are Aden and its Dependencies and the Far East. There is, however, no reason why these local varieties should not be brought to their highest perfection by selection or why improvements should not be possible in curing. The most pressing commercial problem, however, is to oust the foreign cigarette.

This question has been taken in hand in Bengal and Bombay, where efforts are being made to establish exotics. These have met with only qualified success. We can only say, so far, that experiments continue, but whether they will prove commercially successful remains to be proved and indeed seems somewhat doubtful.

At Pusa, where much excellent work has been done by Mrs. Howard on the purely botanical side, attention has mainly been concentrated on the indigenous varieties with the result that a type has been discovered of light colour, fine product and good texture, which has been favourably reported on by the trade as suitable for cigarettes. The cultivation of the plant has also been studied and it has been found that *Sunn* hemp as a green manure is most successful—a result which has been confirmed by Mr. Barry in Madras. In the existing rough methods of cultivation many of the seedlings die off and are lost. This loss, it has been found, can be prevented by making fires on the seed beds and so sterilising them. Some progress has also been made

in the curing process; and by a slight modification of the local methods it has been found possible to preserve the colour better. Selected seed has been distributed to planters and it now rests with the factories to assure a steady supply by offering prices which will compensate for the extra trouble involved.

Mrs. Howard has completed and published her work on the inheritance of characters in tobacco and this will form a basis for attacking the problem of the improvement of the quality of local tobaccos. It has been found that the possibility of obtaining better tobaccos by breeding is certain, and several promising varieties have been isolated during the progress of the work. It now remains, on Mendelian lines, to isolate and fix these qualities which are most desired by the trade.

Burma and Madras should take up tobacco seriously when a staff is available and a great stimulus would be given to the industry if a tobacco expert could be employed. There are many problems connected with curing, fermentation, etc., which can only be handled by an expert skilled in the chemical and manufacturing aspects of the subject.

Oilseeds.—The Indian export trade in oilseeds and vegetable oils is worth on an average about 2,500 lakhs of rupees annually or over 16½ million pounds sterling and only about a-third of the total output is exported. The local consumption of oil, both for cooking and toilet purposes, is enormous. Very little work has yet been done on these crops and they offer a large field both for the botanist and the chemist.

A preliminary classification of the varieties of sesamum has been undertaken in Burma, where the crop, covering as it does something like a million acres, is very valuable. The oil is largely used in cooking and from the seed a rich cattle cake is made which does much to keep the cattle of that province in their excellent condition.

The extraordinary expansion of groundnut cultivation in this province is one of the most remarkable achievements of recent years. From very small beginnings in 1902, the crop is now firmly established in the dry zone, where it has proved a safeguard against the scarcity to which the tract is liable. The crop has also expanded enormously in the United Provinces.

A certain amount of botanical and selection work on rape and sesamum has been done by Mr. Hector at Dacca while Messrs. Woodhouse and Taylor have done excellent work on Soy-beans and have selected the varieties which are most likely to succeed in Bihar.

The subject of oilseeds is a very large one and can only be satisfactorily taken up when the more important food crops have been dealt with. The chemical aspect is an important one, and the commercial qualities of the oils extracted are the dominating factor.

In the case of groundnut, the extraordinary ease with which it can be grown under conditions absolutely unfavourable to any other crops has led to constant cropping year after year with the result that yields have deteriorated and *tikka* disease (which causes shrivelled and dry nuts) has made great ravages. The introduction of resistant varieties and insistence on a correct rotation seem to be the lines of work which call for immediate investigation. Rotation experiments will be particularly important as in some cases it has been found that the crop gives too much nitrogen and makes the soil too rich for certain crops. In Madras Cambodia cotton is proving a promising rotation, while the growth of a mixed cereal crop has also proved advantageous. In the United Provinces it is mixed with maize. In Bombay *tikka* disease has practically disappeared as the result of the introduction of exotics.

The crop has, however, expanded with such rapidity and has proved such a boon to certain tracts that it may only be under a visitation of complete failure or a very serious slump in prices that it will get a set-back and cultivators will be induced to listen to advice.

Tea.—Difficulties with China towards the end of the 18th century turned the attention of the Home Government to the possibilities of India as a tea-growing country and a Government plantation was opened in Assam about 1836. The industry has, generally speaking, prospered from that date and is now firmly established. From the first it has been in the hands of capitalists and is a planters' industry. In Bengal and Assam, the investigation of scientific problems has since 1900

been in the hands of the Indian Tea Association, which receives an annual subsidy from Government. The scientific department of the association now consists of a chemist as scientific officer, an entomologist and a mycologist, with laboratories in Calcutta and an experimental station in Assam, where the problems connected with the industry, such as the study of soils, manufacturing processes, fungus diseases and insect pests are investigated. The effects of various manures on quality and yield are being tested in the field and experiments are being carried out with different methods of pruning and plucking. By the use of oil-cake important results have been obtained at one of the stations in reviving deteriorated tea.

In Madras tea is cultivated in the Nilgiris, Wynaad and the native state of Travancore. Here also it is a planters' industry. The United Planters' Association of Southern India are carrying out a large number of experiments on tea, coffee and rubber and have the assistance of a planting expert who is now a member of the Indian Agricultural Service.

That scientific work on tea has borne fruit is indicated by the fact that while, between 1886 and 1910, the area had increased by 98 per cent. the production in the same period had gone up by 266 per cent., and it is noticeable that in recent years the output has increased much more rapidly than the planted area. The latest figures give the total outturn at 305 million pounds. The United Kingdom and Russia take over 80 per cent. of the total, and the stimulus to Russian trade which is likely to follow the recent prohibition of vodka manufacture will probably largely increase the trade in tea with that country.

Coffee.—Like tea, coffee is also a planters' crop. Sir George Watt is inclined to endorse the view that it was brought to Mysore some two centuries ago by a Mohamedan pilgrim named Baba Budan, who, on his return from Mecca, brought seven seeds with him. There is no doubt that it had found its way to India by the beginning of the 19th century. The industry is practically confined to the Madras Presidency, Mysore, Coorg, the Wynaad, the Nilgiri, Pulney and Shevaroy hills. Coffee has been developed on a large scale since about 1860, but it encounters very severe competition with cheap Brazilian coffee

and it does not enjoy the same prosperity as tea. Exports in fact are dwindling steadily although prices have risen. The problems connected with the industry are being investigated by the planters' association, who now have their own scientific officer, and the officers of the Agricultural Department assist in the investigation of mycological and entomological questions. The decline of the industry seems to be due rather to the competition of Brazil and conservatism in the choice of markets than to any inherent defects in the crop itself.

Rubber.—Rubber is another planters' crop which is coming into prominence, especially in Burma and Madras. The exports in 1913-14 amounted to 1,163 tons valued at 79 lakhs of rupees or over half a million sterling. No scientific work seems so far to have been done, although its liability to disease would seem to warrant some expenditure on mycological and entomological research. The relatively high cost of labour in Burma has caused attention to be given to economical methods of cultivation and management and to care in the preparation of the finished product.

CHAPTER XII.

Fruit: Silk: Irrigation: Drainage.

Fruit.—The institution of a Department of Agriculture in India was hailed by some as the harbinger of a new era with regard to a supply of fruit and vegetables. These hopes have been rudely dispelled and the department has much more important work to occupy it. But the question, as a subsidiary one, has not been wholly neglected and has been taken up in some provinces. The most prominent work has been that of the Howards at Quetta and Robertson-Brown at Peshawar. Burns in Bombay and Graham in the Central Provinces have also devoted some attention to the subject.

It must be emphasized at the outset that, whereas in agriculture the results of improvements can be rapidly made available by the distribution of seed, this is not the case to the same extent with fruit trees. Improved varieties cannot be multiplied so rapidly, and although a certain number of improved plants can be distributed, any general increase must depend on the dissemination of a knowledge of the correct methods of grafting, propagating, etc. The development and improvement, therefore, of fruit culture depend upon the multiplication of central gardens stocked with good varieties and manned by trained superintendents, though it seems unlikely that the general body of fruit growers will exert themselves to any great extent in the matter of plant improvement if they depend on a central garden for replenishing their stock. For the investigation of the main problems two central research gardens—one in the hills and the other in the plains—would probably suffice, and when results have been obtained local growers should be trained in the methods recommended.

It is hardly possible to give details of the work which has been done on various fruits and it is not a subject on which one can lay down general principles. Each variety requires separate treatment and it is to be hoped that a handbook on

fruit culture in India will ultimately be produced by some of the workers on the subject.

An important matter in connection with fruit is its packing and transport. As a rule the general cultivation of any variety of fruit is peculiar to some locality. Within that tract the fruit usually commands no price. It is necessary, if it is to be a source of profit, to carry it to some less favoured locality where there is a demand and where it will command a good price. To these questions of packing and transport the Howards and Robertson-Brown have devoted a considerable amount of attention. The organisation of the fruit industry is a most important matter which must probably in each case be worked out with reference to local conditions. When it is said that a clear profit of ₹1,500 per acre on tomatoes has been obtained in Baluchistan it will be seen that market gardening in India is not to be despised. Combination of fruit-growers so as to obtain freight advantages seems advisable.

Silk.—The silk industry is indigenous in many parts of India and a great deal of work in connection with it has been done at Pusa and by the Bengal Department of Agriculture. Silk manufacture has also engaged attention in Burma, where an improved loom has been introduced by Mr. L. H. Saunders, I.C.S., and at numerous centres throughout India the Salvation Army are doing admirable work.

Eri silk was taken up by Mr. Lefroy at Pusa in the hope of improving its production as a cottage industry. Sericulture has also engaged attention and much progress has been made in the production, weaving and dyeing of the silk, while large numbers of students, from tracts where a development of the industry is possible, have been passed through the short courses on the subject which are given at Pusa.

The industry is scattered and comparatively insignificant. It has steadily declined owing to a variety of causes, and, if it is to be resuscitated, must be taken up on a systematic and organised basis for India as a whole. One main cause of this decline is the organised competition of Japan and other countries where State aid has been freely given, with the result that Indian and Burmese silk no longer hold their own. The

revival of the Indian silk industry is partly an agricultural and partly an industrial problem and there is here a promising field for co-operative organization. The question well merits attention, and the somewhat depressing record of provincial effort leads one to believe that little can be expected unless the matter is taken up on broad lines and for India as a whole.

Irrigation.—The rapid extension within recent years of large irrigation schemes has turned many barren wastes into pleasant places. The fact that in no part of India is the rainfall sufficient to maintain field crops in full growth all the year round has always been a severe handicap to Indian agriculture compared with that of moister regions in the same latitude and irrigation is necessary to make up for Nature's deficiencies. In connection with these large schemes the problems of Indian agriculture are the introduction of new and more valuable crops and the economical use of water. The latter is an engineering as well as an agricultural problem and both departments have concerned themselves with its investigation. In this connection Dr. Leather's enquiry into the water requirements of crops is of importance. But whatever theoretical conclusions may be arrived at, the wasteful tendencies of the cultivators introduce a human factor with which it is difficult to cope.

Apart from the larger irrigation schemes, a great advance has been made in well-boring, well-sinking and pumping in Madras, Bombay, the United Provinces and the Punjab, and, in Madras this has resulted in the artificial lengthening of the season so as to admit of the maturing of a heavy crop of the long-stapled Cambodia cotton. Well irrigation means more capital, more thrift and steadier profits for the cultivator and, especially if an oil-engine be used for lifting the water, the whole agricultural economy of the country is deeply affected. Apart from every other consideration, the saving of animal power for other purposes is a great economic gain. The development of work on these lines under agricultural engineers is one of the most promising with which the department can concern itself.

Drainage.—The question of surface drainage, originally raised by Sir Edward Buck many years ago, has been revived

and has come into fresh prominence in connection with the work done on indigo in Bihar. Without surface drainage of some kind water-logging is bound to occur, and this, as we have seen, will militate against the healthy activity of the plant. In the case of wheat Mr. Howard's experiments showed an annual loss due to this cause of 16 bushels per acre. Again, an enormous amount of fine soil is annually lost through rain wash, and to obviate this a system of surface drainage by means of trenches and grass borders has been devised. Each plot deals with its own rain. This has been tried with success at Pusa and on some of the Bihar estates. A further advantage claimed for the system is the ease with which lands, drained in this manner, can be kept free from weeds during the rains and so put down to cold weather crops in good time. It is claimed that, by this method of treatment, the value of lowlying heavy lands in Bihar, which are capable of drainage, can be doubled.

This method of surface drainage, when each field is separately drained, prevents also the loss of fine soil by surface wash, with the result that a process of natural terracing goes on. Instead of the fine soil being washed away into the lower-lying lands, each field retains its own surface wash and the levels of the lower-lying parts of the fields are raised.

Drainage, however, cannot be regarded only from the standpoint of a particular field or a particular farm. The spill water must go somewhere and a neighbour with low-lying lands may object to the overflow from the drained area. The question must therefore be dealt with on broad lines. Levels and outlets must be examined, drainage maps made, and, if any improvements on a large scale are to be effected, the expert engineer is required.

CHAPTER XIII.

Scientific Research.

It is impossible to describe in any detail the purely scientific work which has been done by officers of the department, nor does this come within the scope of a popular review. Much of this work has already found its application in improvements already introduced, and in the following paragraphs a brief and very general account only of this scientific work is attempted.

Chemistry.—At Pusa the economical use of phosphatic manures on a large range of Indian soils has been demonstrated. Valuable work has also been done on *usar* or alkali land, and the question whether this alkaline condition is increased by irrigation has also been considered.

As water is the prime factor underlying the successful growth of crops its conservation and economical use are naturally of the greatest importance. An investigation of the water requirements of some Indian crops has been taken up, and the amount of water and the period of growth during which the crop requires the principal portion of this water has been determined. The interesting and important discovery has also been made that practically the whole of the water assimilated by a crop is obtained within the root range—from 6 to 8 feet—and that the great stores below this depth are of no real service to the plant. Results obtained from drain gauges at Cawnpore and Pusa as to the rate of evaporation of water from fallow and from cropped land and as to the formation and movement of nitrates in the soil are also of interest.

Important work has also been done on the chemistry of sugar-cane and sugar-beet and the composition of Indian milk. On the latter subject work has been done by Mann and Meggitt.

In the provinces agricultural chemists have, naturally, been first concerned with the soils of the various departmental farms, but they have also, in most cases, been able to attack problems of local importance. Clarke in the United Provinces, Barnes in the Punjab, Somers-Taylor in Bihar and Plymen in

the Central Provinces have taken up sugarcane. Annett has studied the chemistry of date-palm sugar. Mann has devoted his great energies to many subjects, Meggitt is specialising on the manurial requirements of crops, Somers-Taylor has done some work on the chemistry of Soy beans, while Harrison in Madras and Warth in Burma have taken up rice. Warth is concerning himself principally with the commercial aspects of rice, its nutritive qualities, breakage in milling, the food value of its bye-products, etc. Harrison's work on the gases of swamp paddy soils is highly technical, but may have far reaching results in agricultural practice. The practical aspect is that a beginning has been made by explaining the significance of drainage and the film of *algæ* which one finds in rice fields. The practical results will, it is hoped, demonstrate how to use to the best advantage the sometimes limited supply of water available for paddy cultivation and how best to maintain the fertility of continuously cropped paddy fields.

Mycology.—Mycology is the science which deals with fungi and the diseases of plants, the number of which is legion. This, and entomology, offer great fields for work in India but the workers are few. There are in fact only three trained European mycologists in the Agricultural Department and the same number of entomologists. The work is highly specialised and, in mycology especially, there is enormous scope for research. Diseases of plants, as of human beings, must first be diagnosed. But, whereas in medicine long research and experience have evolved methods of treatment which have become more or less standardised, the mycologist has not only to diagnose but also, in most cases, to devise the treatment, and in view of the complexity of the subject the greatest credit is due to the small band of workers in India that results of great practical value have already been obtained.

The first step was a preliminary survey of the important fungus diseases of Indian crops and the formation of a type collection as a detailed examination of each fungus was a necessary preliminary to practical work. There are various ways of dealing with fungus diseases and the treatment is, in many cases, drastic. Spraying is not likely to succeed in India except with garden crops and is not practicable on any large scale. The

destruction of diseased parts of plants or of the whole of a crop by burning is, in many cases, the only effective treatment, but it is not always possible to get the cultivator to agree. *Smuts*, which are conveyed in the seed, may be killed by disinfection while the use of thoroughly healthy seed is another and a very effective way of preventing an increase of certain forms of disease. Finally, for many diseases, the breeding of resistant varieties is the only certain method to avoid epidemics.

Applying one or other of these remedies Dr. Butler has already dealt with potato blight, the rusts of wheat, red rot of sugarcane, the wilt of arhar, and the *tikka* disease of groundnut, but these are only a few of the many investigations that have been carried out.

In its directly practical results an elaborate campaign against bud-rot disease of palms in the Godavari Delta calls for remark. An organised scheme to prevent the spread of the disease, and to stamp it out in the affected area in Godavari and Kistna districts, was started in 1907. The parasite attacks the crown of the palm only, killing the tree by destroying the growing point. The only practicable method of checking the spread of the infection was to burn the diseased tops before spores had time to form. A large staff was employed by the Madras Government to carry out this work and over half a million palms were cut out. In Godavari the disease has been limited to the area originally affected and it is hoped that its spread to other areas has been checked. Madras values the work at a saving roughly of 20 lakhs of rupees annually. A similar campaign against a disease of areca-nuts has saved tens of thousands of rupees.

An important discovery recently made by Dr. Butler is that an eel-worm is probably the cause of the disease of *ufra* in paddy and experiments to combat it are being carried out by the Imperial Mycologist in conjunction with the Bengal department. The losses caused by this pest are enormous and its spread must be checked. The most hopeful method of attack appears to be the destruction by burning of the stubble of diseased fields, and, if experiments prove this to be correct, the remedy is simple and easily applied. This investigation occupies a foremost place in the programme of the department.

It is impossible, in a popular review, to detail the excellent work which is being done in this abstruse subject by Dr. Butler and Messrs. McRae, Shaw and Dastur. The field is unlimited, the problems new. Samples of unknown diseases are being constantly sent up by provinces. In each case the disease has to be diagnosed, the cause discovered, remedies tried and proved. Progress is slow, but it is to the credit of the handful of mycologists in India that they have already achieved so much, and that their work has led to such practical results.

Entomology.—India teems with insect life, some useful, but the majority not, and the scope for entomological work in India is unlimited. The application of remedies is exceedingly difficult. It is only when attacks are concentrated and when wholesale damage has been done that public attention is attracted. The early attacks are not noticed but their effect is cumulative, and it is only when they assume large dimensions that the danger is realised. Prompt remedies are expected, though in many cases prevention would probably be better than cure. Again, in many parts of the country there are prejudices against the only method of cure, which is destruction.

India was fortunate in securing Mr. Maxwell Lefroy as its first economic entomologist. In the short time he was in the country he did an enormous amount of spade work in the collection and study of the habits and life-histories of Indian insects. In addition, he started the training of field assistants, —a most important work, as it is only by multiplying these men that we can hope to get into touch with the cultivators. Next to veterinary assistants there is no class of fieldmen who require greater sympathy and tact. They must understand the cultivator and gain his confidence. Mr. Lefroy's "Indian Insect Pests" and "Indian Insect Life" are monuments to his industry and he has also left in India a number of well-trained Indian assistants. In the absence of entomologists in the provinces his advice was taken on various matters. In Madras good work was done against the hairy caterpillar and the Deccan grasshopper In Bombay successful work was done against the rice grasshopper. A method for controlling potato moths was successfully devised. An enquiry into the industries

dependent on the products of insects led to the starting at Pusa of silk manufacture and the cultivation of lac.

With the increase of provincial assistants much of the work at Pusa consists of identifying specimens and advising as to control or eradication. Except in Madras, which has its own entomologist, work is centralised at Pusa, where reference collections have been got together. Provinces consult the Imperial entomologist and the remedies recommended are applied locally by the entomological assistants under the supervision of the expert officers of the department.

Marked success has been achieved by Mr. Woodhouse of Bihar in the application of two methods directed against insect attacks. Patna is the market-gardening centre of Bihar and the producer of seed-potatoes for Bihar and Bengal. In 1907-08 the potato moth made its appearance in the Patna district and caused such losses to the potato-growers that the area under potatoes is said to have been reduced by one-half, and the quantity of potatoes exported reduced, within four years, to one-third of the former quantity. Mr. Lefroy recommended storage in sand. This proved to be successful, was demonstrated and has been widely taken up. There is no doubt that the production of seed-tubers would have been abandoned if this method of storage had not been recommended and adopted, and this would have meant the loss of an industry worth annually about 14 lakhs of rupees. Again, the trapping by means of *Andre Maires* traps of the *Agrotis* pest, which does enormous damage to *rabi* crops, is estimated to have saved $3\frac{1}{2}$ lakhs a year to the cultivators of the province. In both cases a good organisation and the confidence of the cultivator have contributed to the success of the work.

As I have pointed out, a great amount of spade work has been done by Mr. Lefroy and his successor Mr. Bainbrigge Fletcher. The latter officer has published a very interesting volume on "South Indian Insects of Economic Importance" and the work of provincial botanists, who are at present in charge of entomology in the provinces, is simplified by these books of reference. But no great impression can be made till the number of entomological workers—both European and Indian—is largely increased.

Pathological Entomology.—A fascinating branch of entomological work is under the direction of Mr. Howlett. He starts from the standpoint that agricultural, veterinary and medical entomology have reached a stage at which methods based merely on a general knowledge of life-histories, combined with a more or less superficial study of habits, have been, to a great extent, worked out. This has been done by men possessed of ingenuity and ability, and in most cases it is difficult to see how their recommendations are to be improved upon with knowledge at present at our disposal.

For example, the chief anti-mosquito measures now advocated are the destruction of breeding places by oiling or drainage, the destruction of larvæ by fish, and the use of mosquito-nets—*all measures well known long before the definite connection of mosquitos and malaria was established.* Similarly, the only practical preventive of several animal parasites (practically all the "external" ones) is to wash, spray, or dip the animal in one of a few well-known mixtures such as lime-sulphur or crude-oil emulsion, while spraying the crop with these or similar mixtures is also recognised as the only method of destroying a large number of plant-feeding insects.

There are thus a number of stock methods which are quite familiar to professional entomologists, veterinary officers, and medical men. In some cases these methods can be effectively used at comparatively small cost, but frequently the cost makes it difficult to recommend them unless the crops or animals to be treated are specially valuable and unless a cure can be guaranteed.

Particularly is this the case in India, where perhaps more than in any other country it is *cheap* methods that are required for general use.

Economy and efficiency can be attained only by more accurate knowledge in certain directions, and Mr. Howlett is attempting to ascertain the factors which influence the more practically important activities of insects, such as pairing, egg-laying, blood-sucking, and the choice of food plants.

He advocates the principle of what he terms "control-breeding" for the reduction of noxious and parasitic insects, the

idea being to encourage breeding by the provision of breeding-places, as far as possible ideal, in areas which can be easily controlled.

It is a method which economizes energy to a marked extent, and will, it is hoped, have a wide application when more precise knowledge is available as to the factors which influence the choice of breeding places. Partly with the object of furthering knowledge in this direction Mr. Howlett is paying special attention to chemical influences, and has succeeded in isolating the actual compounds which exert a remarkable attractive influence on male fruit-flies. This it is believed is the first instance of the kind in which the chemical nature of such substances has been ascertained, and the discovery opens up a wide field of research which it is hoped to pursue with the ultimate object of introducing more efficient and economical methods of dealing with insect pests, particularly those concerned in the conveyance of animal disease.

Agricultural Bacteriology.—Bacteria play a large part in vegetable as they do in animal life and agricultural bacteriology concerns itself with their action. The subject falls into two main branches, soil bacteria and plant pathology.

It has long been known that bacteria are among the chief agencies by which physical variations produce a chemical result in the soil. But the detailed connection between cause and effect still remains to be analysed before satisfactory methods of control can be introduced. On this enquiry Mr. Hutchinson is engaged, the main lines of work being on the one hand an investigation of the soil conditions affecting the supply and utilization of combined nitrogen and on the other the production in, and elimination from, the soil of plant toxins or poisons. The work is highly technical and immediate results cannot be expected, but the enquiries are of much importance and may have far reaching effects on agricultural practice.

In the region of plant pathology the wilt of tobacco and the rot of potato tubers have been investigated. Milk problems are also likely to come into prominence as interest in dairying increases.

CHAPTER XIV.

Agricultural Education.

There is probably no subject connected with agriculture on which so much has been written as agricultural education: none, perhaps, in which less has been effected. It is a constant anxiety to agricultural workers who vainly strive after an ideal which seems unattainable. It has been debated at numerous conferences and has been the text of many writers, but there are practically no results to show.

This question has from the outset been obscured by the confusion of two objects,—the collegiate training in advanced agricultural science of those who wish to qualify for the higher appointments in the Agricultural Department or as teachers, and the dissemination in primary and secondary schools of agricultural education amongst the children of the agricultural classes. A further confusion has been introduced into collegiate education by the hope—so far unrealised—of attracting to the college course the sons of landowners so that they may complete their education by obtaining a degree in agricultural science rather than in arts or law.

Primary Schools.—It will be convenient to consider first the question of teaching agricultural principles in primary and secondary schools. Bed-rock was struck in the very first reference we can trace on the subject. The Famine Commissioners, so long ago as 1880, expressed the view *that no general advance in the agricultural system could be expected until the rural population had been so educated as to enable them to take a practical interest in agricultural progress and reform.* These views were confirmed by the Agricultural Conference of 1888, which urged that the measure most immediately necessary was that of educating teachers competent to give instruction of the *required kind.* If the "required kind" had been defined as a *good general education*, many of the subsequent Will-o'-the-wisps would have been avoided. The train-

ing of teachers, moreover, clearly required a teaching institution of a very special kind.

Dr. Voelcker's report dealt with this question. The most important and, probably, the soundest proposition laid down by the conference which considered his report was that it *was most desirable to extend primary education amongst the agricultural classes.* But with the enunciation of this basic principle other resolutions were passed which, while containing much that was excellent, probably led to the extraordinary confusion of subsequent years. Instruction in agriculture, it was laid down, should be combined with the existing system of education; the elementary principles of agriculture should form a prominent subject in the curriculum of village schools; steps should be taken to provide suitable teachers and readers for such schools; education in the lower schools should be of such a practical character as to fit the pupils for technical pursuits, including agriculture, as well as for literary and commercial pursuits; text-books should deal with familiar subjects in simple language and object lessons should be freely used; and the system of training in normal schools should be modified so as to qualify teachers to give education of the kind contemplated.

The numerous discussions which followed, to which it is unnecessary to refer in detail, reiterate the same sentiments. The rudiments of agriculture should be part and parcel of the primary system of instruction. Any system of practical education in rural schools must, for whatever class intended, be given an agricultural colouring because the surrounding objects are themselves agricultural.

It will thus be seen that the dominating idea was that it was necessary *to teach agriculture,* somehow or other, in rural schools. Fortunately this idea has now been abandoned. Agriculture is not a science in itself but a combination in practice of many sciences and to be understood requires a sound general education and a considerable knowledge of science. It is now agreed that agriculture, as such, cannot be taught in schools; that rural education must be general and agricultural education technical.

It seems remarkable that this idea of teaching agriculture should have been so strongly insisted on if any regard had been paid to the actual state of general education. The present figures—and they are a good deal better than they were when these discussions were going on—show that of the total school-going population of India more than half leave school from the second standard. There are just over half a million pupils in Standard III, about 324,000 in Standard IV, 167,000 in Standard V and 119,000 in Standard VI. Figures are not available to show how many of these belong to the cultivating classes, but in any case—even on the most liberal assumption—the proportion of these classes, touched as yet by education, must be very small indeed.

This being the case, it seems clearly undesirable to add to the burden of the infant mind—which is struggling with the effort to learn to read—by weighting it with crude and undigested agricultural knowledge. But in primary schools there is at the same time no reason why the lessons which the pupil learns should not have to do with things with which he is familiar. A reading lesson on rice, for instance, should tell him what he already knows about it from seeing it every day. The animals described should be those with which he is familiar; not the monsters which are only met with in menageries. In the higher classes his arithmetic may contain simple calculations of assessment rates and of the values of crops which his father sells and with which he will himself have to deal. Simple nature study and school gardens will also help to adjust his education to his environment. But the basis of all education in India, as everywhere else, must be a good grounding in the "three R's" and it is only in this way that the intelligence of the pupil can be awakened so as to enable him to read and himself to apply what he reads to his surroundings. The ability to read intelligently must come first, its practical application will follow.

For the time being, therefore, the idea of teaching agriculture in rural schools has been abandoned and no attempt is now made to include agriculture in the curriculum either in primary or secondary institutions. The view now taken is that, instead of endeavouring to teach agriculture as such, an attempt

should be made to impart to the general scheme of education a markedly agricultural colour and to encourage powers of observation and the study of nature with special reference to the surroundings of each school. With this object text-books are being rewritten so as to include lessons on familiar objects; nature study is being taught and school gardens have been started. There are, however, serious difficulties in obtaining suitable teachers. But, as I have already said, more will depend on the natural awakening of the intelligence of pupils by the spread of general education than on specialised training. And in primary schools the essential thing is to establish general education on a firm basis so that the pupils may develop powers of observation and of reasoning. If this be done interest in their surroundings will naturally follow.

Secondary Schools.—The teaching of agriculture in secondary schools does not find favour with the Agricultural Department and is in fact considered a positive disadvantage in the case of boys who propose to enter an agricultural college. It has been observed that applicants for admission to the agricultural colleges are deficient in powers of observation; that they have an insufficient command of the English language and little manual dexterity. To follow the collegiate course it is essential that the student should have a good general education, that his powers of observation should have been developed by nature study, that he should have received some manual training and a grounding in the rudiments of some science such as botany or chemistry—taught practically. Just as a better general education is required in rural schools to awaken the interest of pupils in their surroundings, so also is it necessary in the case of those who wish to enter our agricultural colleges.

Collegiate Education.—Prior to the establishment of Pusa and the organised development of the Agricultural Department, facilities for higher agricultural training existed in Madras, Bombay, Bengal, the United Provinces and the Central Provinces, but it cannot be said that any results commensurate with the time, labour and money spent were obtained—due mainly to the fact that the agricultural schools and colleges were regarded primarily as an avenue to Government service. The training

offered was not taken advantage of to any appreciable extent by those who desired to turn their instruction to practical account in private farming and estate management. This was the class that, in those days, the colleges hoped to attract, but then, as now, these hopes were disappointed. By the beginning of this century doubts began to be expressed whether there was any need in India for advanced theoretical instruction in agriculture and whether it would not suffice if practical knowledge were supplemented by elementary instruction in such subjects as botany and chemistry.

In the statement of policy enunciated in their Resolution of 1904, the Government of India emphasised the importance of Pusa as a training ground, amongst other things, for the teachers of the future and for specialists. If the scheme of agricultural education was to be placed on a broader basis and made really efficient some organisation by which the men required for these purposes might be trained in India was essential and the necessity for such an education was constantly becoming more apparent. But progress must begin at the top and spread downwards. Before education in the vernacular was possible it was necessary that the people of the country should be taught in English so that text-books for general use might be provided. For the production of a satisfactory text-book even of an elementary character in any subject a high degree of training is requisite and in the scientific subjects connected with agriculture such training was at the time only possible in English. It was therefore proposed to train Indians in English so as to make possible in the future the spread of vernacular agricultural education. In addition to the dearth of teachers, trained practical men were required to manage experimental and demonstration farms or to take service with the Court of Wards, Native States or large landowners and it was also thought that a considerable number of students might be attracted if higher agricultural education were made an avenue to appointments in the higher posts of the Revenue service.

These were the ideas held regarding Pusa—but, as we have seen, they have not been given effect to as Pusa, fortunately,

has become a centre of research and has little concern with education. Should, however, it become in the future an educational centre, it will certainly have something to teach.

The scheme of agricultural development as originally drafted by the expert advisers of Government contemplated in the first place, and as the groundwork of the whole policy, the provision of agricultural experts with a farm in each important tract *for the special work that must be done as a foundation for all other research work*, and the extension of research by specialists. In the second place, for the *intermediate* subject of agricultural education, it was necessary to have agricultural colleges to train men for agricultural and research work. Finally, the men so trained would demonstrate what they had been taught. Unfortunately, in the scheme as sanctioned, the agricultural college became the central feature instead of being merely subsidiary to research. In at least two provinces of Northern India expenditure on purely agricultural work was, if anything, restricted rather than encouraged and money went into bricks and mortar instead of being spent on research and experiments.

Any attempt to teach agriculture in India, before investigation has provided the material, is a fundamental mistake which has seriously retarded development, and this mistake has affected, not only elementary, but to a much greater extent collegiate education. In the former case simple general principles might suffice; in the latter more advanced instruction bearing on Indian conditions is required, but such instruction certainly cannot be given until research has provided the material.

We have seen that when in the provinces the departments of agriculture were expanded, an agricultural college was made the central part of each scheme; and practically everything was subordinated to the fetish of agricultural education. The Agricultural Department certainly did not make things any easier for itself. A "standard" curriculum was drawn up in 1906 and amended in 1908 without reference to professional teachers. The syllabus in each subject was drafted by specialists in that subject,—chemistry by the chemists, botany

by the obtanists and so on—with the result that the curriculum consisted of a number of independent courses each complete in itself, but arranged without any reference to the capacity of students in general or of Indian students in particular. The course in each subject was a " specialist " course and there was no inter-relation between the various courses. Their blending in a scheme of general education, their advantage to the practical agriculturist was not considered. As might have been expected, this standard curriculum has broken down hopelessly, as there is not, in Northern India at all events, any educational basis on which such a curriculum can be grafted. Where any success has been achieved this has been due entirely to the higher standard of general education which existed and to the efficiency of the staff. The bitter experience of attempting to work up to this standard curriculum led to its revocation by the Board of Agriculture in 1913. Uniformity is not now insisted on and each province can best work out its own salvation by framing its scheme of agricultural education with reference to the stage of general educational development and agricultural research that may have been reached.

The fact of the matter is that no real progress will be made till we realise clearly what we are aiming at. In the first place there is, and for some time to come must be, a very large section of the agricultural population of India who are absolutely illiterate, or whose education is of a very rudimentary type. In any case it is not such as to enable them to profit by reading. The reasoning faculties are not developed. In such cases there can be no question of agricultural education. Demonstration of improved methods on their own fields and the rule-of-thumb observance of recommendations is the only way in which the Agricultural Department can influence them.

Then there is the son of the small landowner who is better educated and will either farm or manage his own estate. He does not require a " standard curriculum " course, but he would probably be glad of, and benefit by, some shorter course more in keeping with the general education which he has received. An interesting experiment in vernacular agricultural schools in Bombay seems a step in the right direction.

This school takes boys of from 14 to 16 after they have passed the 4th or 5th standard. They are drawn from the sons of village headmen, small landowners and the like. The course is thoroughly practical and lasts two years, and general education is continued along with the special instruction in agriculture.

Finally, there is the collegiate course, which must train men for the Agricultural Departments. Unfortunately, in recent policy, the training of the sons of landholders has also been emphasised as a duty of the colleges, and it is in the failure to attract them that the greatest disappointment has been experienced. Down to 1904 the policy was different. It was felt that something less advanced would meet the case. A special school of a somewhat superior class was needed for the sons of landholders, in which instruction, while perhaps following to some extent the ordinary school course, would include practical training in subjects such as agriculture, land surveying and farm book-keeping, which would be of use to the student in after life. This is practically what the Bombay vernacular agricultural schools are attempting. Unfortunately, with the development of colleges, it was hoped to attract this class of large landholders, and the failure to do so has been the main cause of disappointment.

I think that this disappointment would not be so great if it were realised that a very large percentage of the students who attend the degree course at our British universities do so with the deliberate intention of obtaining appointments. The position in England and India is in this respect very similar. It is true that an increasing number of the sons of wealthy landowners do take an agricultural course instead of going to Oxford or Cambridge and we may hope that this will also be the case in India, but there need not be too much despondency because they are not trooping to us at present. The thorough training of the staff of the department will supply ample scope for the energies of the colleges for some time to come, and the standard will rise with the general standard of education. The time of the staff can also be usefully employed in conducting or supervising less advanced courses, if necessary in the vernacular, for students of the class which the Bombay verna-

cular schools attract. But uniformity is neither necessary nor desirable and it is for each province to work out its own salvation with reference to the existing state of education and local requirements.

It is for the Agricultural Department to decide the standard of general education necessary for admission to an agricultural college. Experience so far has not been encouraging and reports all record a lack of independent thought and application and too much cram. The standard for admission cannot be lowered: it may be raised. The field of selection may thus be further restricted and the course may less and less attract the large landowner. If so, he must be provided for otherwise as local conditions may dictate. Nor will our colleges attract the best available material until prospects are offered no less attractive than those of other branches of the public service or of the professions. The standard of our agricultural colleges is high and a high standard of work is demanded from the Indian professors and assistants. This standard can only be satisfactorily worked up to by students with a first-class general education. The qualifications demanded are as high as those of any other profession and the prospects must therefore be as good.

CHAPTER XV.

Veterinary Matters and Cattle.

The prosperity of Indian agriculture depends greatly on the maintenance in health of the cattle of the country, and this has always been recognised. A Cattle Commission was appointed in 1869 and disconnected efforts were made in the provinces from time to time to deal with cattle-disease. With the development of Agricultural Departments in 1882 the question of a Civil Veterinary Department was also considered, and this, as finally constituted in 1889, consisted of the military veterinary officers of the horse-breeding establishment and a few isolated officers employed in the various provinces. In the earlier stages a great amount of the time of the new department was taken up with horse and mule-breeding, but in 1903 this work was taken away from it and, since that date, attention has been mainly given to questions relating to cattle.

At first the department was manned entirely by officers of the Army Veterinary Department, but since 1901 recruits have been drawn from veterinary colleges in England. The provincial organization consists of superintendents, who are members of the Civil Veterinary Department; deputy superintendents, who are graduates of provincial colleges; inspectors—either graduates or promoted veterinary assistants—and veterinary assistants. The ideal, which is being worked up to gradually, is that there should be a veterinary assistant in each *taluk* or township.

The backbone of the organization is the veterinary assistant, who is trained at a provincial veterinary college or school. A remarkable feature of veterinary education which reflects the greatest credit both on the teacher and the pupil, is the success which has been achieved, notably in the Punjab and Burma, in training these assistants in the vernacular. The best assistant is the son of the small cultivator who is accustomed to handle cattle, and who can easily gain the confidence of the people. In some provinces he is a peripatetic officer, going about from one outbreak of disease to another and applying

remedies—medical or segregative. In others he has a local dispensary from which he dispenses medicine or advice, visiting villages as necessity arises. The inspector supervises the work of a number of veterinary assistants and also attends serious outbreaks of cattle-disease. The veterinary establishments are being rapidly developed in all provinces and in the last ten years the number of assistants has more than doubled. There are now 909 assistants, 95 inspectors and 19 deputy superintendents. In provinces administrative control rests with the Director of Agriculture.

Veterinary Instruction.—For the training of the staff there are veterinary colleges at Bombay, Lahore, Calcutta and Madras and a veterinary school at Rangoon. A course for veterinary assistants is given, and special and post-graduate courses for inspectors and deputy superintendents. The teaching is of a thoroughly practical type, and the results are very gratifying.

Research.—A large amount of research work has been done by officers of the department, notably by Colonels Pease and Evans, Majors Baldrey and Walker and by Mr. Gaiger and Dr. Hartley. A camel specialist is employed for the investigation of the many diseases of that susceptible animal. The Hissar cattle-breeding farm under Lieutenant-Colonel Farmer has attained more than a local reputation.

But as provincial officers have many other demands on their time, continuous research work is difficult and such work is concentrated at the Imperial Bacteriological Laboratory at Muktesar. Muktesar is 23 miles north-east of Naini Tal and 13 miles south-east of Almora; magnificently isolated—a condition desirable, if not essential, for concentrated scientific research. The systematic investigation of the diseases of animals in India began in 1890 when Dr. Lingard was appointed Imperial Bacteriologist at the College of Science at Poona. But the climate of Poona was not favourable for bacteriological research or for the manufacture of vaccines and sera, and Muktesar was eventually selected, where work in a modest way was commenced in 1895.

Rinderpest has always been the scourge of India and the necessity of finding a remedy early engaged attention. In 1896 the distinguished bacteriologist, Professor Koch, visited Muktesar and demonstrated his bile method of inoculation. During the next few years rinderpest and the preparation of a potent serum were the principal interests of the laboratory and with the discovery of this serum the scale of operations rapidly extended. A temporary stoppage was caused by the destruction of the laboratory by fire in 1899, but a new one was soon built and a branch laboratory was also opened at Bareilly so that a certain amount of research work might be carried on during the winter months. The Bareilly laboratory is being enlarged considerably so that the manufacture of anti-rinderpest and other sera can go on all the year round. Between 1901 and 1904 the preparation of sera for anthrax and hæmorrhagic septicæmia, of black-quarter vaccine and of mallein (the test for glanders) was taken up. In 1908 Dr. Lingard retired and was succeeded by the late Lieutenant-Colonel Holmes, C.I.E. By his sudden and untimely death Government have lost a brilliant scientist and a capable administrator.

The staff of the Imperial Laboratory has recently been strengthened and now consists of an assistant bacteriologist, a physiological chemist and a pathologist.

Many difficulties beset veterinary officers in India in their attempt to fight cattle diseases. Treatment by approved methods cannot be forced upon cattle-owners and although segregation may be insisted on and disobedience of rules punished the areas are so vast and difficult to control that no direct attempt to eradicate any endemic disease is feasible. Again, even if eradication were possible within British India, there is always the risk of infection from across frontier lines. In view of these numerous difficulties the veterinary departments are content to suppress outbreaks of disease as they occur.

To meet such conditions the most efficient weapons are *sera* and *vaccines*, and these can only be used within the consent of owners. It is the highest tribute, not only to the soundness of the recommendations made by the Imperial Laboratory, but

also to the patience and tact of officers of the department that there is an increasing demand for these remedies. The prejudice of the cultivator has been overcome; his confidence has been gained.

The discovery of these sera and vaccines has completely revolutionised the practice of veterinary science and the success achieved in India has been marvellous. It is true that the immunity given is only temporary, and the object aimed at is not so much the preservation of each animal treated as the control of the epidemic and the prevention of the spread of the infection. The animal of any individual cultivator may die, yet he willingly takes the risk.

As rinderpest or cattle-plague is the most prevalent disease in India the main work of the Muktesar laboratory is the manufacture of anti-rinderpest serum. The object of anti-rinderpest inoculation is to protect healthy cattle at the time of an actual outbreak by inoculating them. They are then turned out with the infected herd in order that an opportunity of contracting natural infection and a larger immunity may be given. The risk seems great and it is not surprising that considerable opposition was at first encountered. After a few years, however, the successful results obtained, combined with the patient propaganda of provincial officers, overcame this opposition, and cultivators now eagerly demand inoculation when an epidemic breaks out. In consequence, for some years, the demand exceeded the supply, but this has been remedied by improved methods of manufacture which allow of a larger output. So popular is the Muktesar serum that large indents have been received from the Straits Settlements, Egypt and Rhodesia.

Vaccines and sera are also manufactured for hæmorrhagic septicæmia, anthrax and black-quarter, although the necessity for their application is fortunately not so great.

The Veterinary Department has succeeded to a remarkable extent in securing the affection and confidence of the people. An old Burman once said to me that the veterinary officers must be remarkably clever men. When I asked him why, he replied, that if he was ill he could tell the doctor his symptoms and how he felt. But a dumb animal could not do so,

and yet the veterinary officers could find out what was the matter and administer the proper cure. Cases are not indeed unknown of human subjects being brought for treatment to veterinary hospitals.

Cattle Insurance.—The greatest calamity which can befall the small cultivator is the loss of his cattle. It is a knock-down blow. In some parts of the country the kindly consideration of his neighbours supplies him with the money to repair his loss. But the homely cultivator would rather be independent of charity, and, in some provinces, cattle insurance societies on co-operative lines have been started. These are numerous and successful in Europe, but in India this development of the co-operative movement is in its infancy. There can, however, be no doubt of the advantages of co-operative cattle insurance if it became general. Agricultural development would be assisted; the cultivator would be saved from the grim nightmare of losing his cattle—his chief stock in trade—without any hope of replacing them; rural indebtedness would be reduced; and a spirit of independence fostered. Mutual responsibility leads to better attention being given to cattle, as each member of the society has a direct interest in the health of every animal insured. A further stimulus to care is that the society pays only two-thirds of the value of the animal. Further, no indemnity is paid when the cause of death is a contagious disease, if the member has failed to carry out rules or to report the outbreak. The educative value of the system cannot be overestimated.

Cattle-breeding and Milk-supply.—The important question of cattle-breeding, with which is linked that of milk-supply, has been the subject of disconnected effort in some of the provinces. The subject was discussed at the last meeting of the Board of Agriculture, which considered that the production of the " dual purpose animal " should be aimed at so as to combine breeding for draught and milk in the same operation. The improvement of the milk yield by the importation of bulls of high-yielding milk breeds from Europe is not in India a practical proposition owing to the great susceptibility of such cross-breds to rinderpest. At the same time the producing powers of the best Indian milking breeds can probably be improved by selection

and an experiment on these lines is in progress with the Montgomery herd at Pusa.

If any real advance in cattle-breeding is to be made efforts must be co-ordinated and work carried out on a fairly large scale. One idea that has been mooted is that an Imperial officer should be appointed and that, working on the excellent material available in the military dairy farms, he should have high-class bulls and buffalo bulls which would be distributed among the provinces. A record of their progeny would be kept and in course of time a pedigree stock of the various breeds would be built up. Co-operative societies would supply the organised machinery necessary for controlling the distribution of these bulls and for recording results. The officer would also advise local departments as to the lines on which provincial cattle-farms should be run. On some such lines as these cattle-breeding might be placed on a systematic basis throughout the country and method introduced into the business. Till now fancy and caprice have run riot and there has been little method or system.

An Imperial officer of this kind might also control dairying schools, where courses in the practical handling of cattle and instruction in dairying processes would be given.

CHAPTER XVI.

Conclusion.

In the preceding pages I have attempted to give a general account of the agricultural development which has taken place since the Department of Agriculture was organised on its present basis. For more detailed information I would refer those interested to the numerous publications of the department. *The Agricultural Journal of India*, which is issued quarterly by the Imperial department, may profitably be studied by the general reader interested in agriculture and kindred subjects. The Imperial department also issues an annual report which contains a record of the progress made from year to year, both in the Imperial department and in the provinces, while the report of the Agricultural Research Institute and College, Pusa, gives a more detailed account of the work of each of the sections of the institute.

The results of scientific research, both at Pusa and in the provinces, are published from time to time as memoirs of the department classified under Botanical, Chemical, Entomological, Bacteriological and Veterinary. The institute also issues a series of bulletins on subjects of more general interest.*

In the provinces, each department issues an annual report and occasional papers and leaflets, all of which can be obtained from the local Director of Agriculture or from the Government Press. Cultivators' leaflets are generally issued both in English and in the vernacular.

The Proceedings of the Board of Agriculture in India are also of interest. The Board meets once every two years, alternately at Pusa and in one of the provinces. It is attended by members of the Imperial staff and by representatives of the provinces—official and non-official—and many important questions connected with agricultural and veterinary subjects are discussed.

* The publications of the Imperial department can be obtained from Messrs. Thacker, Spink & Co., Calcutta, or any of the authorised agents for the sale of Government publications.

Material Progress.—The decade to which this review refers has been marked by an organised and systematic effort to improve the agriculture of India. The labours of earlier years were spasmodic and disconnected, and left little impression on the general agricultural condition of the country. Scientific workers were few. Their work was not co-ordinated and they received little encouragement either from officials or from the cultivators in whose interests they were working. Their presence and their efforts were viewed at best with sympathetic toleration or amused unbelief.

But all this is now changed. The Agricultural Departments are now regarded as an integral and important part of the administration. The few European and Indian workers of 1905—158 in all—now number 866; their labours are concentrated and co-ordinated; they now work on general schemes of development. Farms and demonstration plots, formerly scattered and disconnected, have increased from 35 to 374 and work on them is concentrated on main problems and not dissipated, as used to be the case over a number of subsidiary and unimportant enquiries.

As a result the department can claim credit for great advances in general agricultural practice. Cultural and manurial problems have in many cases been solved. Local machines have been improved and adapted, or better implements introduced. Real and substantial work has been done on the improvement of such important crops as wheat, cotton, rice, sugarcane and tobacco. The general principles of crop improvement have been definitely settled. The most important crops have naturally been dealt with first, but given more men and more money all the crops of India will be taken up.

Money spent on agriculture is a good investment but material results are difficult to gauge. Many factors have to be considered. A whole industry, threatened by destruction, may be saved by the discovery and application of preventive and protective methods. The treatment of the palm industry and areca-nut industry of Madras and the protection of the potato crop of Patna are illustrations of this kind. Again, there are the direct gains following the introduction of new or improved

crops, improved implements, well-boring, and improved methods of cultivation. We may, at a conservative estimate, claim that the increase to the value of the agricultural products of India, as a result of the labours of its Agricultural Departments, is already about 3½ crores of rupees annually or over £2,300,000. This is the result of only ten years' work, and it must be remembered that every year will show a progressive increase. On the debit side we have an annual expenditure on agriculture which has risen from Rs. 8,81,124 or £58,742 in 1904-05 to Rs. 51,30,652 or £342,043 in 1913-14.

Economic Progress.—But the progress of the past decade has been more than merely material. A mutual understanding and friendship has grown up between the officers of the department and the cultivators. The former have long ago given up the idea that the East has nothing to teach the West. They have found that the only way to real progress is a due appreciation of local conditions and difficulties, based on an accurate study of indigenous methods, and a sympathetic co-operation with the cultivator. Without this they labour in vain. Agricultural development cannot be fostered by compulsion or force. The adoption of the methods recommended is entirely optional and the cultivator need not take them up unless he wants to. He certainly will not do so unless he is convinced that they are better than his own. The days of suspicion and mistrust are however gradually passing away and with the cordial and increasing co-operation of the cultivator an era of real progress has begun.

But if we are to influence to any extent the vast agriculture of India some arrangement must be devised to deal with large bodies of cultivators, as it is an economy of time to deal with a group of people rather than with single individuals. The physical capacity, even of members of the Agricultural Department, has its limits. As we have seen, the stages of their work are research in the laboratory or the field; experiment on a field scale; demonstration on demonstration farms; and multiplication of seed on seed farms for distribution. But it is clear that direct distribution to individual cultivators is much less efficient than distribution to a group of cultivators or a whole village. In the former case control would be difficult, if not impossible,

and the improved seed would rapidly disappear; in the latter the new seed can be concentrated, controlled and established in a defined area.

Co-operation.—The decade which has witnessed this striking improvement in agriculture has also seen the rapid growth of the co-operative credit movement—that great factor in all schemes of economic development. It is a happy omen for India that the two lines of development should have come into prominence simultaneously. By the establishment of the co-operative movement the propagandist work of the Agricultural Department has been immensely simplified. Improvements can be taken at once to a group of cultivators bound together by common interests instead of to isolated individuals working selfishly. By the provision of credit improved methods, expensive though they be, have been brought within the reach of the small cultivator. And by co-operation, facilities for the more favourable disposal of his produce have also been provided. The small cultivator is lifted out of his narrow and restricted surroundings and brought into direct touch with outside markets.

Co-operation must be the bond between the cultivator and the department, between the cultivator and the market, between the cultivator and the large body of well-to-do Indians whose sympathy and interest, prior to the advent of co-operation, found an outlet in Agricultural Associations. Co-operation and sympathy must be the driving force all along the line. There must be less talk and more work and the "dignity of labour" must be recognized. All are working for a common cause—*to improve the position of the individual cultivator and to increase the material wealth of India.*

The economic and social regeneration of India lies in the co-operative development of her agriculture and her industries. Fortunate are they who have been given the opportunity to assist in this development. Let the motto of the department be "Sympathy and Co-operation": *its one great aim being to work with the people and for the people, for the people's good.*

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